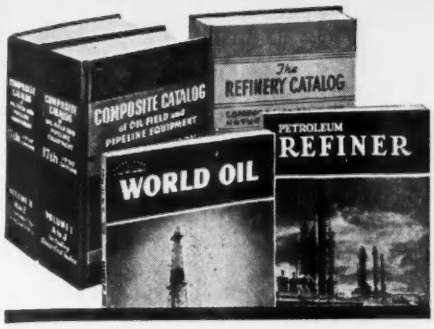

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PETROLEUM REFINER and The REFINERY CATALOG for the refining-natural gasoline industry

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Editor's Page

COMPLACENCY ISN'T GOOD

THE KOREAN SITUATION isn't good, and the quicker U. S. government officials and the American people realize that this country is in grave danger the better off we will be. So far the measures adopted run the great risk that they will provide too little too late.

●

THERE IS NO IMMEDIATE ray of hope in the present situation. Superior numbers and armament of the enemy are forcing our troops to retreat steadily. This is all that can be expected under existing conditions. Because it will be some time before we can muster and move sufficient men and military materiel so far away, conditions are likely to get a lot worse before they improve. We may be driven out of Korea completely.

Furthermore, the Korean trouble is but the curtain-raiser. There is no assurance that fighting will be confined to Korea. Whatever the outcome of the war in Korea, it likely will be but a short time until the next Soviet attack—perhaps at a more vital spot; with each move designed to further weaken the U. S. so it will be easy pickings for the Communists.

We are committed to save already threatened Formosa. Indo-China, Iran and Yugoslavia are other points that look particularly dangerous and soft. Then there is Western Europe, the Philippines and even our own continental areas. Piecemeal military policies cannot hope to insure the security of all these regions. We will be spread too thin unless fuller measures are adopted at once.

●

AT THE SAME TIME, even a partial mobilization of U. S. industry would strain national economy more seriously than it did 10 years ago when America started to become the arsenal for the free people of the world. We do not have the large unemployment which existed in 1940. Taxes are much higher now, and still the country has been running further into debt each year. In 1940 there were more than 8 million unemployed workers, and the national debt was only $43 billion. Today, only 3 million workers are jobless, a much larger portion of our industrial capacity is at work, and the national debt exceeds $267 billion.

Moreover, despite the United Nations, we can not expect to receive much help from other countries. Conditions are vastly different now; it is the U. S. that is in jeopardy this time—not England or France. Neither of those nations has much to offer, and probably will not be inclined to give a great deal of assistance anyway. Therefore, except for token help, this is the United States alone versus Russia. It is our way of life against Communism.

●

IN VIEW OF THE GRAVE DANGER, it is alarming that there seems to be so much complacency and so little realization that we are faced with an all-out conflict against a heavily armed and determined enemy. Too much business-as-usual attitude prevails, with both government officials and the people apparently having this feeling. Too many are looking upon Korea as an isolated incident, a small disturbance. There is a tendency to boast that American forces will win because they have never been beaten. American military units always have won because they have had the greatest amount of warfare implements, and this must be made true again—if we are to win.

It must be recognized that this country is in grave danger. It behooves us to get busy and meet the crisis at hand. There are endless questions demanding decisions. This is no time for complacency, but a time for decisions—which it is to be hoped will be wiser than the international policies followed by the U. S. government between World War II and the Korean war.

If the Korean war serves the purpose of waking us up in time, it will have performed a vital function for all free men and free nations of the world.

Warren L. Baker

NO OTHER EQUIPMENT—no other method of cementing—provides such assurance of successful "first-time" cementing as the exclusive Baker Principle of *whirling* the cement up and around the casing which is effectively centered in the well with BAKER MODEL "G" CASING CENTRALIZERS.

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You are assured of RESULTS when you use Baker Hook-Ups as pictured at right using a BAKER WASH-DOWN WHIRLER GUIDE SHOE (Product No. 121) with BAKER MODEL "G" CASING CENTRALIZERS spaced throughout the cementing area to provide *maximum centering force at the critical cementing point.* Then, with a BAKER CEMENT FLOAT COLLAR (Product No. 101 M & F) positioned a joint or two above the shoe, you have the world's best "float valve" for safety, plus a "stop" for the cementing plug so that cement tailings are retained inside of the casing.

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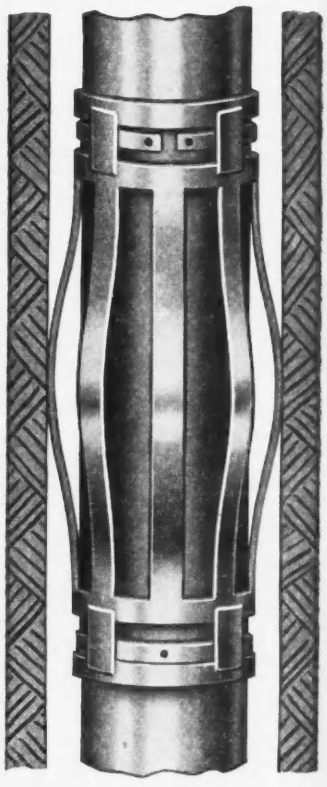

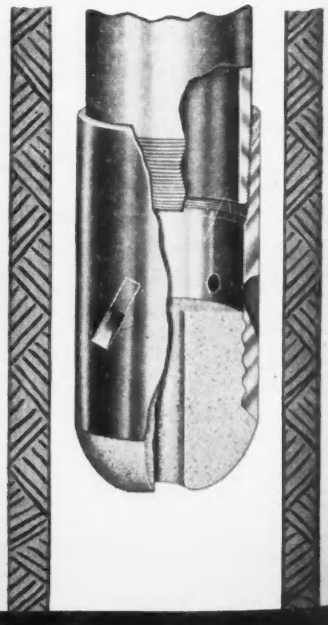

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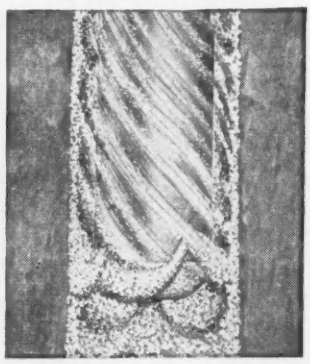

The "whirling" motion given to the cement slurry as it is discharged from a Baker Wash-Down Whirler Shoe causes the cement to encase the centered shoe joint with a more uniform body of cement, and reduces to a minimum the hazard of channeling.

The Changing Panorama

In Fighting Communism Abroad Let Us Not Embrace It At Home

By L. J. LOGAN, Associate Editor

THIS is a time for clear thinking by all Americans, as well as a time for unity of purpose and action in resisting Communist aggression abroad. As we brace ourselves to come to grips with the tyranny of Communism in a long and grim struggle if necessary, let us make sure that liberty continues to prevail and bless and vitalize us at home also. Even if we must fight another all-out, global war and make temporary sacrifices of personal freedoms, let us burn into our minds the concept that in fighting against tyranny we are fighting for liberty. And let us burn this concept also into the minds of those to whom we delegate authority for coordinating our national efforts. Let us stand not only as a liberty loving but also a liberty demanding nation, and let us demand that men we place in positions of authority have a deep reverence for our liberties and a disposition to respect them in time of war as well as peace. Even in fighting a war, compulsion and regimentation should not exceed necessary limits. The less we are herded around by our own necessary bureaucracy, the stronger and more effective will be our fight against foreign tyranny.

There is danger that excessive powers may be delegated to the President and executive department of government, especially if a full-scale war breaks out. The "Defense Production Act of 1950," introduced in House and Senate July 20, proposes to grant the President such broad powers that he could nationalize any or all industries whose output "is needed for the national defense."

For the past 2 years the National Security Resources Board has been designing an Emergency Powers Act that would give the government total power over men, industry and materials if enacted. The controls would dwarf those of World War II in speed of imposition and effect upon citizens. The proposed measure would give the government sweeping power to impose priorities and allocations, draft industry and labor and keep them producing, requisition property, censor communications, regulate prices, wages, and rents, and ration all important goods used by consumers and industry.

President Truman already has about 350 "war powers," left over from World War II. Many existing laws are dated to expire at given periods "after cessation of hostilities." Many others contain such phrases as "when, in the opinion of the President, the safety of the United States demands it," or "whenever, in his judgment, a sufficient national emergency exists," and "in case of actual or threatened hostilities."

Steel allocation priorities are authorized under extension of the draft law, giving priority to defense orders and permitting plant seizure and punishment for non-compliance.

Main titles of the proposed Emergency Powers Act include the following: emergency contracting authority; creation and powers of government corporations; defense facilities; production loan guarantees; acquisition and disposal of real property; priorities and allocations; plant seizure; exemption from anti-trust laws; authority to requisition; import and export controls; censorship of communications; price and wage stabilization; excess profits tax; renegotiation of contracts; special amortization of emergency facilities; employment controls; settlement of labor disputes.

Although a government conducting a modern war admittedly needs broad powers, even war does not necessitate concentration of all power in the executive branch and complete substitution of executive orders and directives for laws enacted by Congress. During World War II Congress left to administrators the making of many arbitrary orders that laws would have made unnecessary. Furthermore, there is need for honesty in keeping "emergency powers" temporary instead of allowing them to be perpetuated beyond the emergency for which they are authorized. For a country resisting tyranny, it is exceedingly disquieting that government action can yet be taken under 350 different "war powers" still in effect in 1950—5 years after Japan surrendered. Many of the powers granted to government during the war were blended into a postwar movement for socialization of America. Similar perpetuation and abuse of powers delegated to Washington in a new war could mean for America only half a loaf as the fruit of victory; a triumph over foreign tyranny made empty by entrenchment of tyranny at home.

In a recently issued pamphlet, Earl Browder, former leader of the Communist Party in America, discussed the American trend toward communism. "State capitalism leaped forward to a new high point in America in the decade 1939-1949," he stated. ". . . State capitalism, in substance if not in formal aspects, has progressed farther in America than in Great Britain under the Labor Government, despite its nationalization of certain industries, which is a formal stage not yet reached in America; the actual, substantial concentration of the guiding reins of national economy in governmental hands is probably on a higher level in the U. S. A."

In appraising a list of 22 specific items of American governmental policy, Browder stated: "They have the single feature in common that . . . they express *the growth of state capitalism* . . . [This is] an essential feature of the confirmation of the Marxist theory. . . . It represents the maturing of the objective (material) prerequisites for socialism, the basic factor which makes socialism inevitable. . . ." The 22 items were: "1. Government deficit financing. 2. Manipulation of bank reserves requirements. 3. Insurance of bank deposits. 4. Guarantee of mortgages. 5. Control of bank credits. 6. Tinkering with the currency system. 7. regulation of installment buying. 8. Price controls. 9. Price support for farm products. 10. Agricultural credits. 11. RFC loans to business corporations. 12. Social security systems for workers. 13. Various benefits for veterans. 14. Government housing. 15. Public works to provide employment. 16. Many projects for the conservation of natural resources. 17. Juggling of the tax structure. 18. New tariff regulations. 19. Government-organized foreign loans. 20. The Employment Act. 21. The President's economic committee. 22. Last, but by no means least, stimulated war armaments production on a large scale."

While resisting the tyranny of Communism abroad, we must also prevent the maturing and flowering of seeds of Communism that sprout on our own soil.

Report from the Observatory

Greater Production Necessary

By **RAY L. DUDLEY**, Publisher, and **WARREN L. BAKER**, Editor

PROSPECTS for further gains in oil consumption of sufficient magnitude that it will be necessary to boost present near-record volumes of production and refining activities to all-time peaks in the near future, stand out in the current petroleum industry economic picture.

• • •

HIGHER DEMANDS for refined products were indicated by trends and prospects of normal civilian consumption before the outbreak of military hostilities in Korea. The Korean war and other expanded U. S. international commitments now presage the need during coming months for even greater amounts of oil than anticipated previously.

Although enlarged requirements for military purposes have not yet materialized to any appreciable amount, greater civilian and industrial use has caused consumption lately to exceed that of the corresponding period of 1949 and 1948, thereby creating peak levels for this season of the year. Gasoline demand recently has been at all-time peaks, and both distillate and residual fuel oil have been consumed in larger quantities than in the preceding year. Prospects for further enlargement of consuming rates have been indicated by continued heavy sales boosting the number of cars and oil burners in use to ever greater record volumes.

Military operations will need enlarged quantities of petroleum to support the Korean war now stepping up in tempo, to fill storage against the possibility of a big all-out war, and for intensified training activities. War preparation activities undoubtedly also will boost industrial consumption of petroleum. Whether the U. S. is entering a big scale war now or it is to come later, there is to be immediate larger military use of petroleum, the volume of increase depending on whether this country is merely to prepare for war or is actively to fight on a major scale.

The combination of strong civilian demand and the forthcoming requirements for war seem to assure a definite need for larger volumes of petroleum in the immediate future.

• • •

REFINERY RUNS have been stimulated by the recent high rate of consumption, a sharp increase carrying crude charged to stills to the greatest level in history during July. Additional gains are due in view of indicated higher consumption.

Refinery runs have climbed steadily and sharply during the past 3 months, averaging 5,850,000 barrels daily during the first half of July in contrast with a daily average of 5,231,000 barrels in April. The early July average also was 680,000 barrels per day above July, 1949, rates.

• • •

CRUDE PRODUCTION has logically responded to increased refinery runs, rising to 5½ million barrels daily in July, up 600,000 barrels over last March and 900,000 barrels per day above July of 1949. Nevertheless, crude stocks have not increased because of such high refinery runs.

Crude production will advance again in August, strong domestic demand and the war having prompted a 107,000-barrel per day boost in Texas allowable. Prospects are that U. S. production of crude and condensate will approximate 5,600,000 barrels daily in August, or just 90,000 barrels short of the all-time peak reached in December, 1948. Some additions to crude stocks appear probable in August, but conditions warrant the carrying of larger inventories than now exist.

• • •

ADDITIONS TO STOCKS of distillate and residual fuel oil have occurred recently as enlarged refinery runs increased the output of refined products. However, this is in line with normal summer operations, and it is significant that all major product inventories remain well below a year ago with the exception of gasoline. Stocks of motor fuel continue at approximately the same volume as in the corresponding period of 1949, despite record production in recent weeks.

Distillate fuel oil inventories have been growing at a faster rate than in 1949, being only 10 million barrels less than a year ago in mid-July although they had been 16 million barrels under year ago quantities at the beginning of June. This gain is highly desirable, the installation of a large number of new oil burners indicating the industry should enter the winter months with more heating oil in storage than in 1949. Meanwhile, residual fuel oil stocks have been holding steady at 25 million barrels below 1949 quantities.

Prospective high refinery runs in August may cause additional growth of refined product stocks, unless the military situation causes a sudden upsurge in demand. However, the outbreak of military hostilities indicate petroleum stocks should be increased as a national security safety measure.

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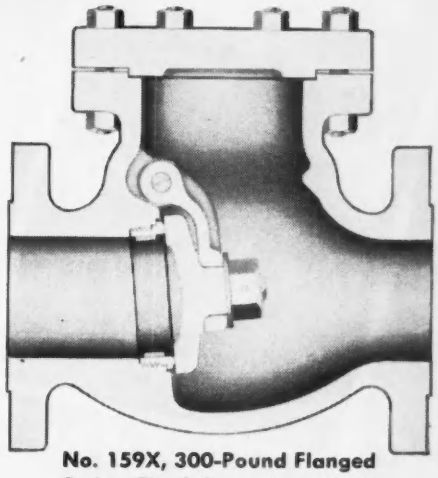

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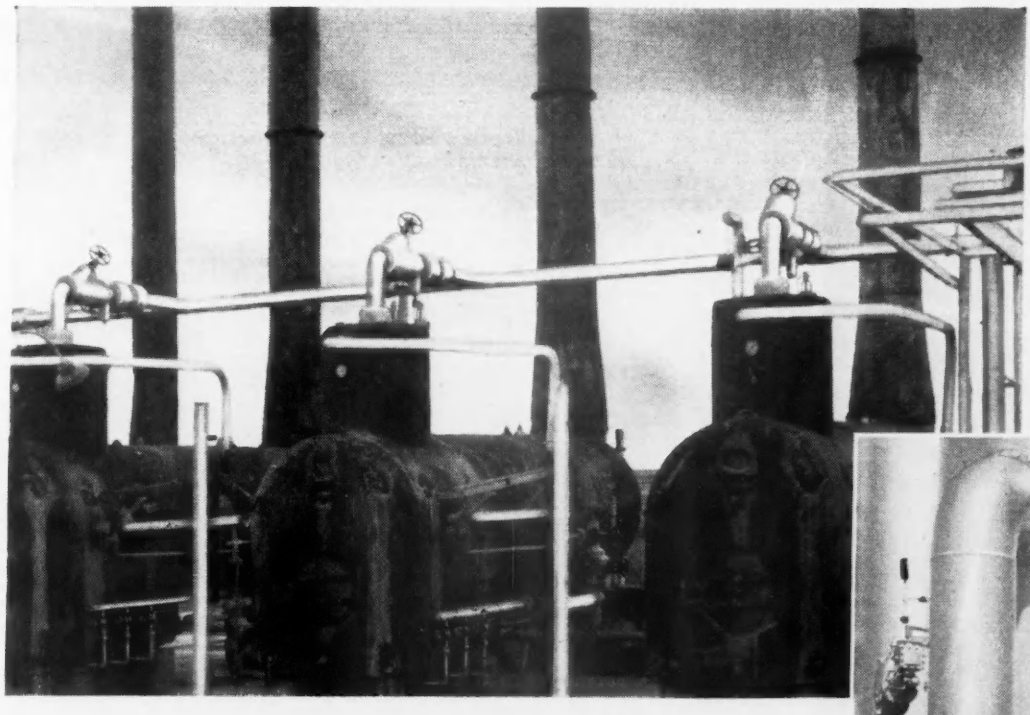

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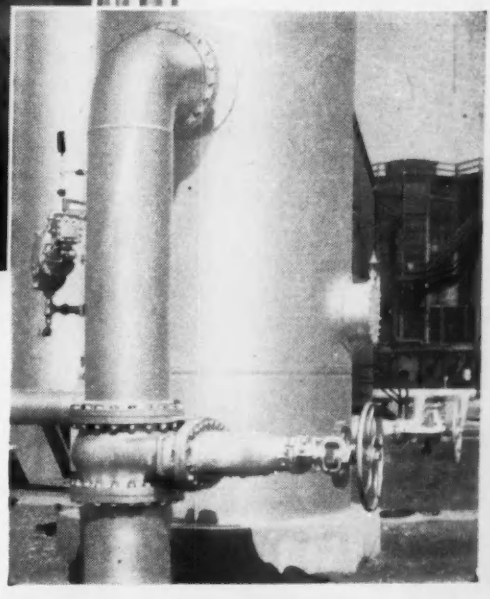

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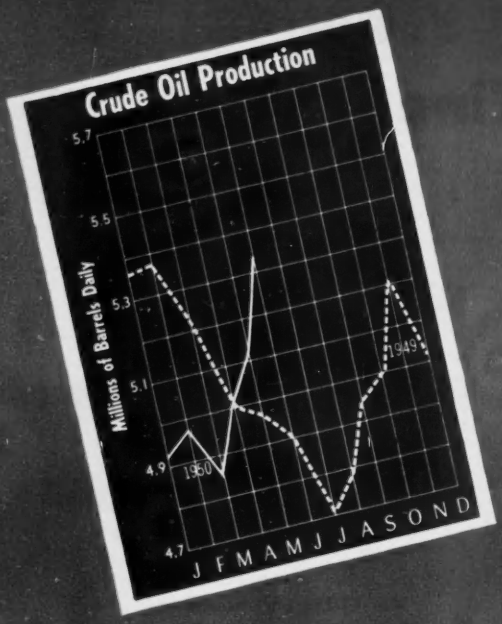
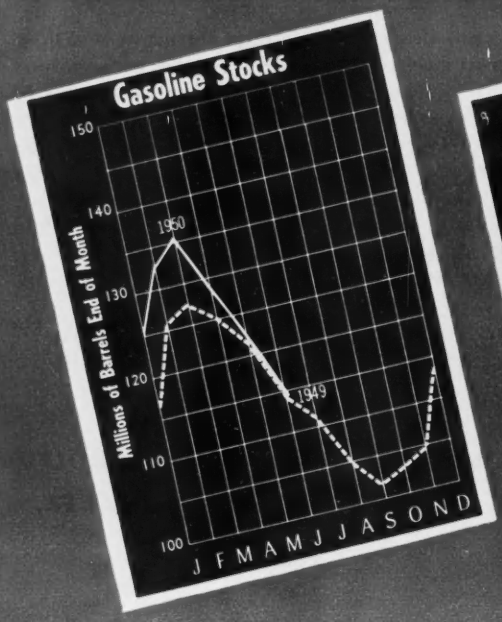
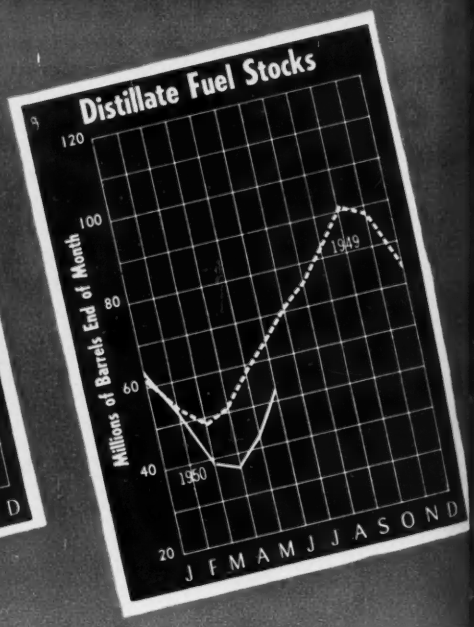
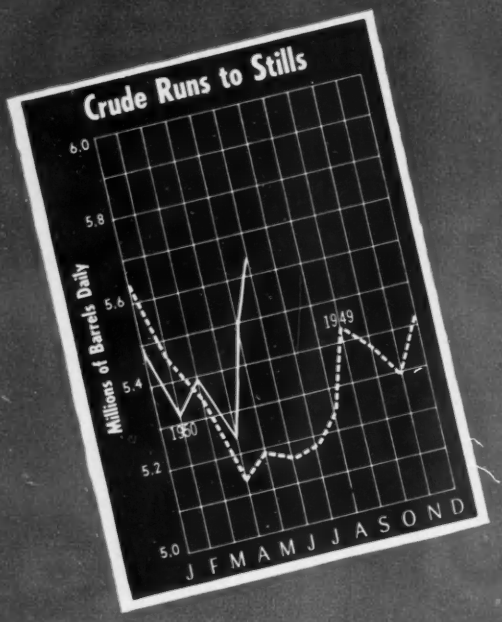
Petroleum

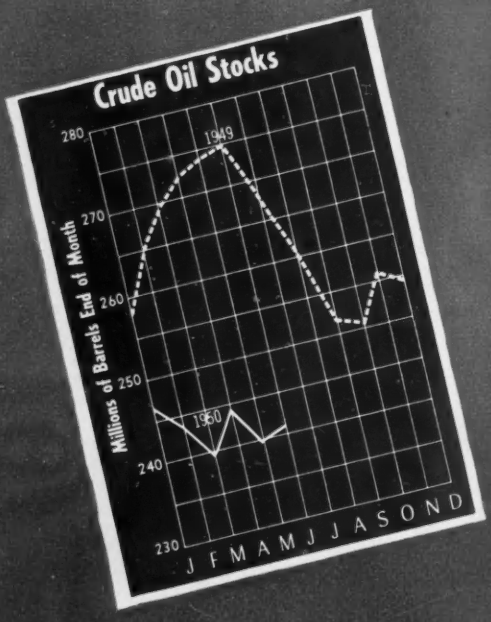
By CECIL W. SMITH
Statistical Editor









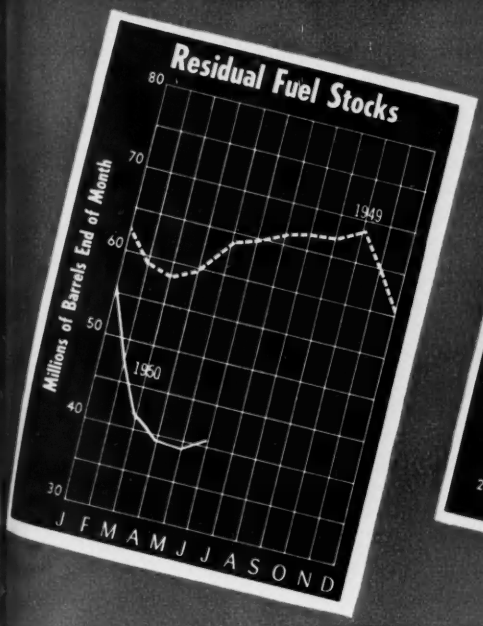


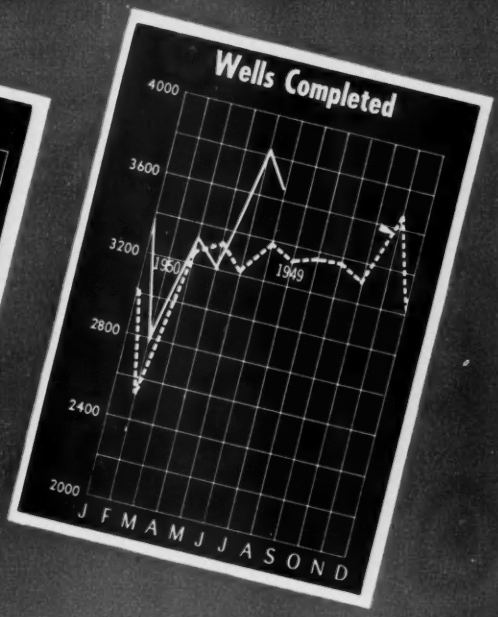
State Crude Oil Production

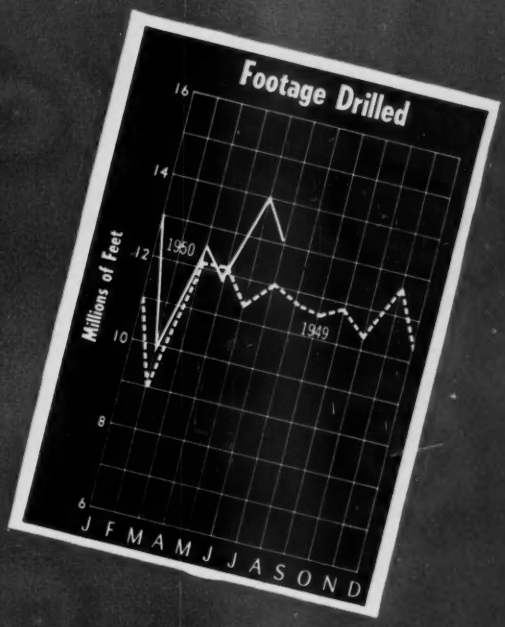
(THOUSANDS OF BARRELS)

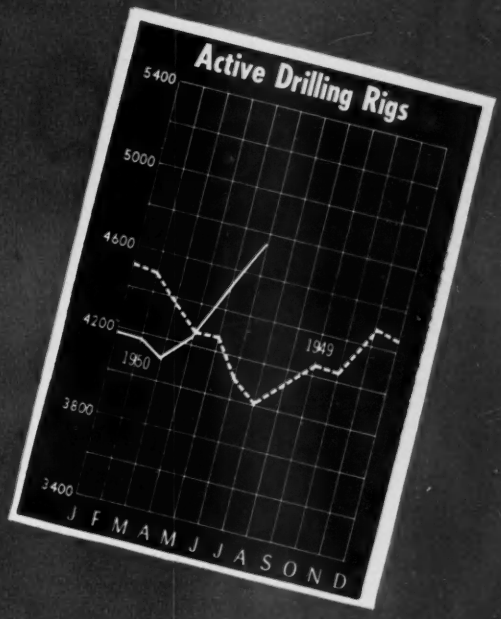
STATE or DISTRICT	DAILY AVERAGE PRODUCTION				TOTAL FIRST SIX MONTHS		
	June, 1950	May, 1950	June, 1949	% Diff. June, 49-50	1950	1949	% Diff. 49-50
Alabama	1.8	1.6	1.2	+ 50.0	293	217	+ 35.0
Arkansas	83.4	83.6	78.3	+ 6.5	15,388	15,291	+ 0.6
California	869.0	855.8	920.7	— 5.6	155,997	169,746	— 8.1
Colorado	59.7	59.2	65.3	— 8.6	10,898	11,797	— 7.6
Florida	1.5	0.9	1.4	+ 7.1	196	232	— 15.5
Illinois	173.2	176.8	179.0	— 3.2	31,126	31,610	— 1.5
Indiana	30.2	29.2	26.4	+ 14.4	4,950	4,403	+ 12.4
Kansas	277.4	276.5	276.1	+ 0.5	50,583	52,130	— 3.0
Kentucky	26.0	26.3	22.5	+ 15.6	4,574	4,118	+ 11.1
Louisiana	587.9	549.2	514.2	+ 14.3	100,027	94,297	+ 6.1
North Louisiana	131.7	133.0	119.2	+ 10.5	31,102	22,192	+ 40.1
South Louisiana	456.2	416.2	395.0	+ 15.5	68,925	72,105	— 4.4
Michigan	42.0	47.1	44.0	— 4.5	8,060	8,085	— 0.3
Mississippi	109.3	104.0	99.7	+ 9.6	18,339	19,643	— 6.6
Missouri	0.1	0.1	0.2	— 50.0	14	22	— 36.4
Montana	21.6	21.3	26.9	— 19.7	3,879	4,684	— 17.2
Nebraska	2.0	1.5	0.6	+233.3	352	114	+208.8
New Mexico	125.3	124.7	133.6	— 6.2	22,969	24,148	— 4.9
New York	14.2	13.9	11.9	+ 19.3	2,210	2,151	+ 2.7
Ohio	9.2	9.3	10.5	— 12.4	1,653	1,710	— 3.3
Oklahoma	423.5	412.1	405.4	+ 4.5	74,234	76,122	— 2.5
Pennsylvania	30.8	29.7	32.0	— 3.8	5,541	5,813	— 4.7
Tennessee	0.1	0.1	.....	.....	12	4	+200.0
Texas	2,290.0	2,129.1	1,914.8	+ 19.6	369,400	380,591	— 2.9
Dist. 1—South Central	28.5	27.5	26.1	+ 9.2	4,840	4,800	+ 0.8
Dist. 2—Middle Gulf	135.5	124.5	121.1	+ 11.9	21,856	25,093	— 12.9
Dist. 3—Upper Gulf	420.3	397.0	370.5	+ 13.4	68,530	74,669	— 8.2
Dist. 4—L. Gulf-S.W.	213.4	197.9	188.3	+ 13.3	34,646	36,916	— 6.1
Dist. 5—East Central	34.4	31.9	34.6	— 0.6	5,581	7,211	— 22.6
Dist. 6—Northeast	373.5	351.0	329.8	+ 13.3	60,560	66,979	— 9.6
Dist. 7-B—N. Central	69.8	67.1	59.7	+ 16.9	11,677	10,983	+ 6.3
Dist. 7-C—West Central	62.6	58.6	42.2	+ 48.3	9,677	8,218	+ 17.8
Dist. 8—West	716.1	643.2	527.3	+ 35.8	110,089	106,656	+ 3.2
Dist. 9—North	143.7	139.0	136.6	+ 5.2	24,637	23,679	+ 4.0
Dist. 10—Panhandle	92.2	91.4	92.8	— 0.6	16,412	16,162	+ 1.5
Utah	3.2	3.1	0.8	+300.0	561	61	+147.5
Virginia	0.1	0.1	0.1	.....	14	20	— 30.0
West Virginia	8.0	8.0	7.9	+ 1.3	1,428	1,353	+ 5.5
Wyoming	153.6	154.3	129.8	+ 18.3	28,168	22,782	+ 23.6
Total United States	5,343.1	5,117.5	4,903.3	+ 9.0	910,866	931,144	— 2.2

Trends in the U.S.









Crude Oil and Refined Products Trends

(THOUSANDS OF BARRELS)

MONTH	CRUDE OIL			GASOLINE		DISTILLATE FUEL		RESIDUAL FUEL	
	Production Daily	Runs to Stills Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month
1948:									
April	5,484	5,540	234,506	2,396	109,289	978	32,564	1,303	35,527
May	5,502	5,668	231,318	2,486	108,552	992	38,551	1,314	41,123
June	5,544	5,632	231,412	2,529	104,518	998	45,835	1,280	44,213
July	5,522	5,631	230,955	2,494	98,839	994	56,045	1,264	49,448
August	5,577	5,621	231,954	2,532	95,445	1,038	65,887	1,248	55,009
September	5,435	5,376	237,302	2,416	90,518	961	73,854	1,154	58,682
October	5,632	5,594	243,972	2,490	92,426	1,069	79,992	1,268	61,456
November	5,675	5,672	250,066	2,551	95,589	1,081	80,658	1,277	64,865
December	5,688	5,720	256,254	2,626	103,697	1,106	71,475	1,299	64,021
1949:									
January	5,365	5,641	258,648	2,538	116,621	1,063	61,584	1,348	62,508
February	5,376	5,480	265,216	2,484	126,054	1,004	53,937	1,282	59,398
March	5,224	5,352	269,341	2,470	127,443	993	48,923	1,258	58,190
April	5,012	5,141	272,520	2,494	125,351	846	51,231	1,147	59,668
May	4,972	5,195	273,912	2,585	121,602	813	57,442	1,138	63,576
June	4,903	5,162	274,691	2,597	114,041	771	64,730	1,041	64,628
July	4,704	5,173	267,586	2,613	111,217	835	71,553	1,040	66,084
August	4,780	5,241	260,585	2,593	104,879	902	76,037	1,078	66,843
September	4,940	5,427	251,689	2,617	101,799	1,002	83,213	1,110	67,117
October	5,997	5,373	250,932	2,643	103,287	1,001	90,643	1,141	68,673
November	5,210	5,293	256,010	2,594	104,707	962	88,212	1,180	65,112
December	5,024	5,475	253,356	2,633	111,521	1,032	75,207	1,203	60,193
1950:									
January	4,922	5,483	246,610	2,575	125,298	1,048	63,932	1,209	55,808
February	4,967	5,316	243,750	2,552	132,796	1,026	52,206	1,172	47,828
March	4,878	5,336	241,098	2,539	133,766	938	37,777	1,154	41,860
April	4,968	5,193	244,498	2,508	128,057	977	37,530	1,041	39,979
May	5,118	5,504	239,659	2,648	121,801	1,022	41,659	1,065	39,128
June	5,343	5,642	240,943	2,752	114,267	1,016	52,941	1,073	40,649
June, 1950 Change:									
In Month	+225	+138	+1,284	+104	−7,534	−6	+11,282	+8	+1,521
In Year	+440	+480	−33,748	+155	+267	+245	−11,789	+32	−23,979
Week Ended:									
July 15, 1950	5,495	5,806	238,485	2,759	111,739	1,026	58,658	1,147	42,708
July 16, 1949	4,725	5,130	272,148	2,588	111,464	814	68,622	1,112	67,564

Monthly News Analysis

Industry Is Cooperating With Government On War Problems

Drastic regulation of the petroleum industry on a wartime basis is not expected to result from the Korean conflict, despite the fact that the industry has ready a detailed plan for full conversion to military needs. The war already has had the effect of postponing decisions on Congressional oil price investigations, tax bill plans and other pending issues, and virtually killing all chance for restrictive action against imports. The military indicates that for the present it will rely on voluntary cooperation by the industry, although that procedure may require some legislation to provide anti-trust clearance. Military stockpiles presumably can supply enough oil for the present, and the Korean campaign is scheduled to be fueled largely from the Middle East.

Shipments of oil to the Far East have been banned by the Government to prevent such cargoes falling into the hands of North Korean sympathizers. Both State and Commerce Departments have clamped a tight embargo on Hong Kong as well as Macao. Under the new regulation, the Government has reduced to $25 the limit of export of aviation fuel, automotive and other motor fuels that may be shipped without license. Hitherto the limit had been $1000.

Every refiner in the United States with a daily capacity in excess of 2500 barrels has an output schedule on hand ready for instant invocation. The overall pattern has been set by the Petroleum Committee of the Munitions Board together with the Military Petroleum Advisory Board, and is designed to provide a six months oil supply for military needs in case of widespread war.

Walter S. Hallanan, chairman of the National Petroleum Council, in a letter to Interior Secretary Oscar L. Chapman, said:

"The petroleum industry is ready to contribute its full share in meeting any emergency which may come to America's door. The industry has a detailed plan under which it can turn overnight all of its facilities to the national defense. The development of this far-seeing program has been due very largely to the cooperative effort between the industry and the government, as carried on by the National Petroleum Council and the Oil and Gas Division of the Department of Interior, with the full cooperation of the Department of Defense."

The petroleum industry and its suppliers of equipment and materials would be affected, along with all other industries, by enactment of the administration's proposed economic controls legislation. Introduced in both House and Senate July 20, the measure if passed would become "The Defense Production Act of 1950." It would establish a system of priorities and allocations for materials and facilities, authorize the requisitioning thereof, provide financial assistance for expansion of productive capacity and supply, strengthen controls over credit, regulate speculation on commodity exchanges, and by these measures facilitate production of goods and services necessary for the national security.

The Independent Petroleum Association of America has appointed an oil and gas field materials committee to work toward assuring for domestic producers enough steel and oil field materials for doing essential drilling and development. A spokesman for IPAA said that operators already have been confronted with difficulties in buying casing and warned that perhaps steel normally going to pipe mills was being diverted to other industries. The independent producers say they fear that government regulations growing out of the international situation will breed a scarcity of oil field materials such as that experienced during World War II. Russell B. Brown, IPAA general counsel, declared that in the World War II period the Office of Production Management and its successor the War Production Board failed to recognize the importance of maintaining active drilling and thus maintaining producing ability and that this mistake should not be made again. Brown also cautioned against over-emphasizing development of foreign oil facilities for national security reasons and deprecated moves in Congress toward restoring war time price fixing and controls as exercised by the Office of Price Administration.

Government Interference In Pricing Not Good For Public

It is questionable if the public interest is constructively served by the constant attacks of government on oil industry prices and pricing practices. In many cases the attacks are against retail and wholesale prices of refined products. But crude prices also are at times criticized as being too high and unfair to the public or too low and unfair to independent producers.

As regards both product and crude prices, the government especially attacks company announcements of price postings and charges collusion among companies to adopt identical prices. In the California anti-trust case collusion on both crude and product prices has been charged. In the Middle West the government has attacked announcements of product prices by major marketers as conducive to adoption of the same prices by competitors.

These many attacks on openly publicized prices indicate governmental condemnation of them and governmental desire to suppress them and force all buying and selling of oils onto a basis of strictly private sales and contracts.

That the government is thus serving the public interest is doubtful. Making prices public should tend to intensify rather than reduce competition. Certainly, when product price reductions are publicly announced, competing companies quickly lower prices to meet the competition and the public promptly gets the benefit of lower prices. And if an increase is necessary, any company will be reluctant to initiate it unless it is fully justified and fairly certain to be followed by competitors. Similarly, under public posting of crude prices, purchasers cannot long maintain postings that are either higher or lower than supply and demand justify. If crude postings are too low, producers will sell to other purchasers; if too high, producers will offer more supply than can be handled. Before posted prices for crude became the rule many years ago, purchases were on individual contract basis, as the government seems to want to be again. But it was found that public posting of prices was a better way, economically, competitively, and ethically, assuring the independent producer a fair market price at all times, with any necessary readjustments promptly made, and also assuring the public of getting competitively priced products derived from properly priced crude.

In answer to questions from the press about current pricing policy of that company, an official of Standard Oil Company (Indiana) stated that over a year ago the company decided on a basic charge in its pricing policies. The changes were made after a careful study of legal developments in the pricing field, including legislation and Supreme Court decisions. The new policy discontinued any formulative method of pricing and substituted pricing of products at individual supply points on basis of local economic and competitive conditions. At the same time the company

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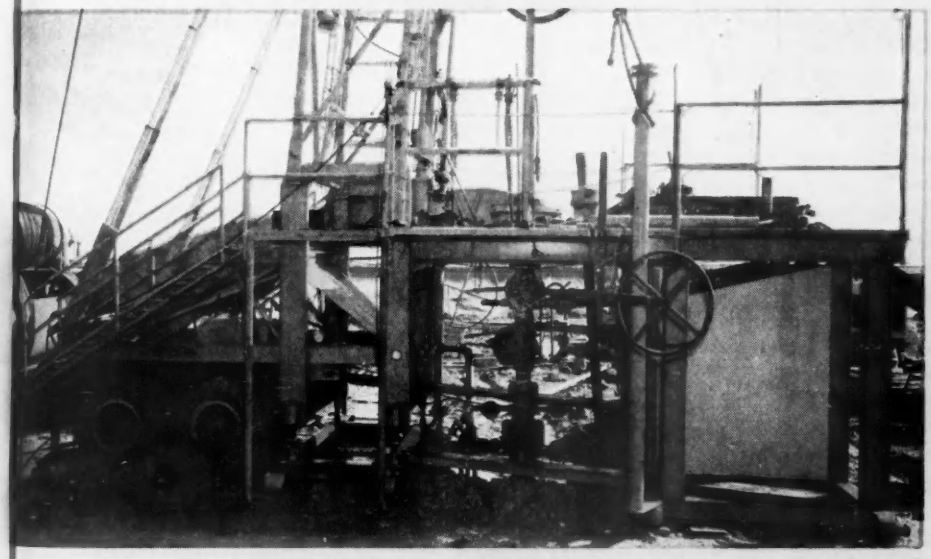
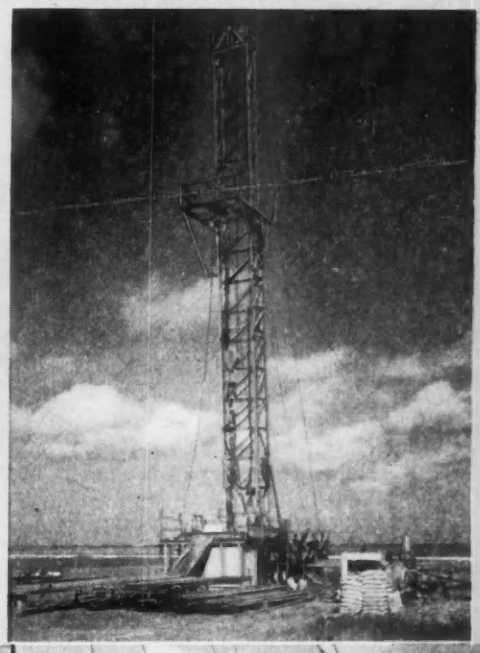


The 16' x 16' derrick floor provides plenty of working space and is high enough for blowout preventers and wellhead connections. Note optional location of doghouse.

Mast is erected with built-in hydraulic system and raised to full height with traveling block and drilling line. The rig is usually ready for work in less than three hours.



Any "Cardwell" single engine rig is mounted on the Trailermast frame and can be removed for operation under conventional derrick. Note convenient walkways and built-in rathole digger.

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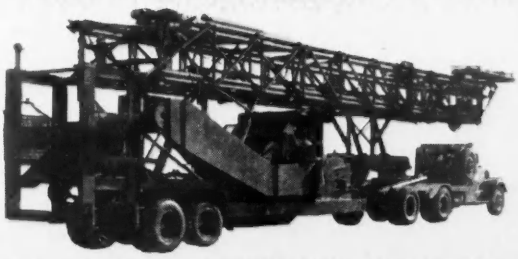

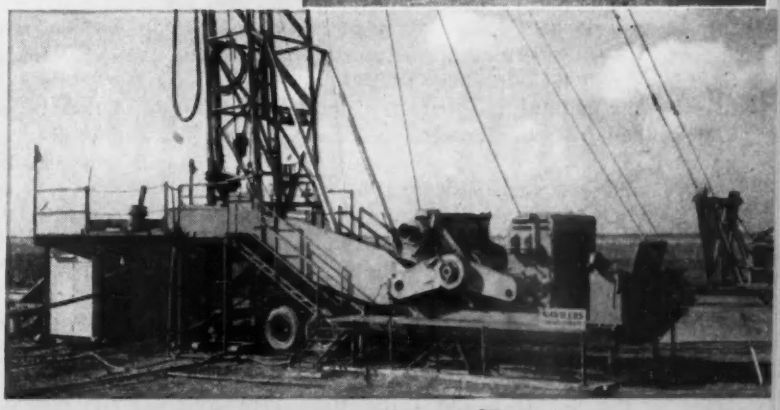

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discontinued public announcements of price changes. Though Standard realized that information as to changes in its prices for petroleum products had been a matter of public interest, the company reluctantly concluded that for legal reasons it must discontinue the public announcements. The trend in court decisions had been such that government agencies were sustained in claiming that a public announcement of a price change could be construed legally as the equivalent of an "invitation" to a company's competitors to follow the price change. If a competitor subsequently did follow such a price change, it was then possible for the government to claim, and the courts tended to support the claim, that this completed a "price conspiracy" between the two competitors and a violation of the federal anti-trust laws. The statement said Standard felt this was an unrealistic attitude for the government and the courts to take but saw no alternative but to discontinue public announcements. Consequently, the company now posts its local prices at each bulk plant or other supply point, as required by law in many states.

Gas Industry Investment Due To Be $11 Billion By 1955

In its phenomenal postwar expansion program, the gas utility industry will have more than doubled in value of facilities within a 10-year period, unless war or other cause interferes with scheduled plans. Whereas the value of gas utility plant was approximately $5 billion at the beginning of 1945, the industry spent nearly $3 billion for additional facilities in the five years 1945-1949, and has planned to invest another $3 billion in the 5 years 1950-1954. From a $5 billion industry at beginning of 1945, the industry will have grown to a $11 billion enterprise at the beginning of 1955 if expansion proceeds as planned.

The whole gas utility industry will spend about $3,140,000,000 in construction of new and expanded facilities in the 5 years 1950-1954, according to a survey of the American Gas Association. This will include about $2.75 billion by the natural gas industry and $388 million by other branches of the industry.

These additions to facilities will bring up to $6.10 billion the gross construction expenditures made or planned for the 10 years, 1945-1954. During the first 5 years of the postwar construction activity, 1944-1949, the gas utility industry spent $2.96 billion for new facilities, including the $143 million spent for purchase of the Big Inch and Little Big Inch lines. Having started at a moderate rate, this construction program accelerated and was at an all-time high in 1949, when $959.2 million were spent for new and expanded facilities.

Anticipated construction expenditures during 1950, according to AGA estimates, should set a new record. It is expected that for the first time in history, the industry will spend more than $1 billion in a single year in an expansion program. Construction activity is expected to abate only slightly in 1951, with possibly more marked declines in the last 3 years of the 1950-1954 period. However, plans for construction in the latter part of the current 5-year period are tentative for many companies and those concerns have hesitated to provide all inclusive figures for those years. This indicates that actual expenditures could exceed those allowed for in the AGA estimates.

Of the projected expenditures for 1950-1954, new transmission lines account for $1.41 billion, and all but $200 million of this amount is allocated for 1950 and 1951.

Construction plans for production and distribution facilities are more definite. Indicative of the industry's expectations of serving an ever-increasing number of consumers, such anticipated expenditures have been revised upward from earlier estimates and will continue at high levels throughout the current 5-year period. The survey indicates that $1.11 billion will be spent for new distribution plant, including 80 percent by natural gas companies and 20 percent by maufactured, mixed, and liquefied petroleum gas utilities; while $426 million will be spent for production and storage facilities, including development of new underground natural gas storage reserves.

Recent Developments Reduce Clamor for Curbing Imports

The question of petroleum imports, which developed in 1949 and the first half of 1950 into an important issue in the industry and in Congress, suddenly has become only an academic subject. This has happened because of two significant developments: (1) abrogation of the U. S.-Mexico reciprocal trade agreement, and (2) outbreak of the Korean war.

Abrogation of the U. S.-Mexico trade pact at the end of this year will reinstate the tariff provisions on oil as specified in the prior U. S.-Venezuelan agreement. That means that the 10½ cents a barrel tariff on oil will apply only to imports equaling not more than 5 percent of crude processed in U. S. refineries for the preceding year. After the 5 percent quota has been reached, the duty is automatically increased to 21 cents a barrel. This does not mean, however, that all oil imports will be subject to the tariff rise. In the General Agreement on Tariffs and Trades of 1947, concluded at Geneva, the tax on gasoline was reduced from the original 2¼ cents per gallon to 1¼ cents per gallon and on lubricating oils from 4 cents to 2 cents. All other products not covered in previous agreements were reduced by 50 percent. Actually then, about one-third of U. S. oil imports are protected under a variety of trade agreements, an amount equal to about 275,000 barrels a day.

The outbreak of the Korean war held up presentation of the Patman report to President Truman and several groups dropped their agitation for oil import restrictions.

However, the Independent Petroleum Association of America continues to press its fight against imports and has turned its fire on the residual fuel oil problem. IPAA argues that last year, one out of every five barrels of crude produced in this country was made into residual fuel.

The association says that market outlets for heavy crude have been restricted 48 percent, while the price has been depressed 19 percent and the producers' income 58 percent. This trend continued during the time that imports increased, and IPAA contends there is some relationship present. Also, the Association says, domestic refiners "have been injured by the increased importation of residual oil through a depressed and restricted market that has made it uneconomic for these refiners to supply their normal portion of the residual market."

Crude oil imports into the United States have in some cases been excessive and have contributed to reduction in leasing and exploration activity, according to the recent report of the oil import committee of the House Small Business (Patman) Committee. This study was the most searching yet made of the controversial import issue. It required a year of hearings and preparation and requires 148 closely printed pages for its presentation. It was made under the subcommittee chairmanship of Eugene Keogh (Dem., N. Y.) and in cooperation with all the importing companies.

Findings of the committee are:

1. There is a level at which oil imports damage the domestic industry, but opinions vary as to what this limit is. Any formula designed to fix the level must be flexible.

2. A distinction must be drawn between crude oil and residual oil, and each treated separately.

3. "Some imports of crude oil are and have been in excess of reasonable levels for several months. These excesses have had adverse effects on some of the domestic producers. The overall effects to date have been manifest principally in a diminution of income."

4. "Excessive crude oil imports and

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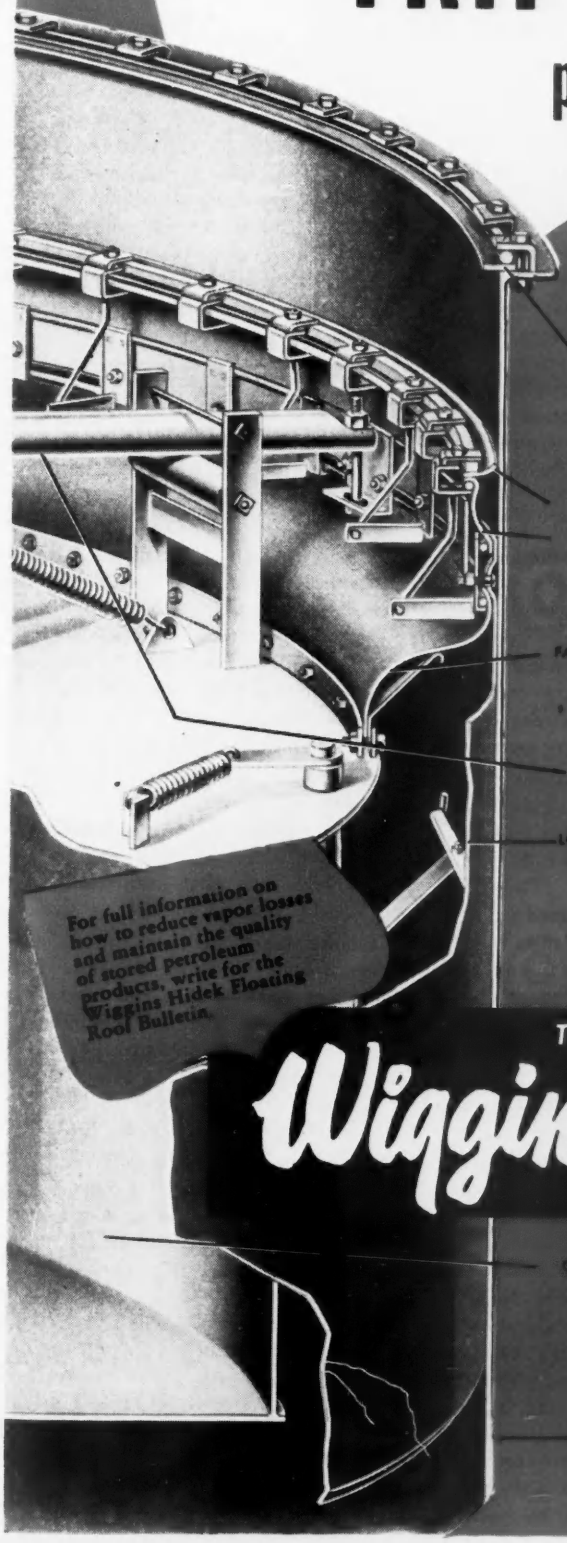

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fear of further increases have contributed to curtailment in leasing and geophysical activities, which undoubtedly will have some effect on future exploratory and developmental activities."

5. "Imports of residual fuel during the past 17 months have undoubtedly displaced some domestic crude oil production and had a depressive effect on some segments of the domestic industry. Domestic purchasers could further assist in offsetting these displacement disadvantages by purchasing from domestic producers those crude oils which would be most economically feasible for the making of residual fuel oil."

6. "Legislative restrictions on imports of crude petroleum and products, either by quota or restrictive taxes, are repugnant to certain contractual commitments contained in existing international trade agreements to which this Nation is a party."

7. "The policy that imports should be permitted to supplement but not supplant domestic production, while good in theory for some segments of the oil industry, if enforced according to strict interpretations, might possibly create repercussions in international relationships, international trade and domestic employment, and high cost to consumers, of such serious nature that the national economy and national security would be adversely affected."

8. "Most of the principal importers have failed or refused to recognize the equitable necessity for mutuality of flexibility in cushioning the fluctuations of domestic petroleum requirements."

9. "The effects of imports on maintenance of adequate oil supplies to meet a national emergency is a paramount factor to be considered in establishing any policy restricting oil imports. Oil imports in excess of reasonable levels would have adverse effects on drilling and development activities and thus retard a healthy growth of productive capacity in the U. S.; on the other hand, restrictions at less than such reasonable levels would adversely affect the availability of oil from other Western Hemisphere sources in time of national emergency."

$30.2 Billion Oil Industry Is Fourth Largest In U. S.

Following a vast expansion program during the several years after World War II, the petroleum industry had increased its total investment in the United States to an estimated $30.2 billion at the close of 1949. In terms of gross assets employed, it is the fourth largest industry in the country, exceeded only by agriculture, railroads, and the public utilities.

This estimate was made by Joseph E. Pogue and Frederick G. Coqueron of the Chase National Bank in conjunction with their detailed annual study of the financial transactions of 30 major oil companies, which comprise about two thirds of the petroleum industry in the United States.

The study, "Financial Analysis of 30 Oil Companies for 1949," has been published in pamphlet form.

In the report it is estimated that the total gross assets employed by the entire petroleum industry in the United States amounted to $30.2 billion at the close of 1949. The industry's fixed assets, or plant, property, and equipment, are carried at an estimated gross value of $23.5 billion, before deducting reserves; current assets are placed at $6.3 billion; and other assets at $0.4.

The $23.5 billion of gross fixed assets representing the industry's investment in property, plant, and equipment are subdivided by departments as follows: production, 54.4 percent; transportation, 14.0 percent; refining, 18.6 percent; marketing, 11.7 percent; and all others, 1.3 percent.

"In general," stated the authors, "the study reveals that the petroleum industry continued to make effective and dynamic use of the mechanism of capital formation so essential for the maintenance and expansion of economic activity."

The industry was in a period of readjustment in 1949, according to the study, following the postwar expansion which started in 1946. Prices underwent some reduction, and gross operating revenue of the 30 companies was down 5.7 percent from 1948. Net earnings of the group were $1,408 million, a decrease of 27 percent from the previous year.

During 1949 the 30 companies paid in dividends to stockholders $564 million, nearly 19 percent more than in 1948 and a sum which represented 40 percent of available earnings. The remainder of earnings was retained in the business. The increased dividends were made possible by a decrease in outlay for plant, property, and equipment. Expenditures of this kind amounted to $2.3 billion in 1949, about 16 percent less than was spent in 1948.

Cash earnings of the 30 companies amounted to $2.7 billion in 1949, leaving $2.1 billion for other purposes after dividends. Expenditures for fixed assets and other investments aggregated $2.4 billion, requiring $0.3 billion from outside sources. Funds raised through financing and sales of assets totaled $0.7 billion. Of this amount, about $0.4 billion were added to working capital.

In 1949 the 30 companies obtained funds totaling $641 million from banks, insurance companies and the public in these proportions: 42.6 percent from insurance companies, 36.7 percent from the public, and 20.7 percent from banks.

Borrowed money and equity capital employed by the 30 companies at the end of 1949 amounted to $14.4 billion. About 18 percent of this amount was in the form of long-term debt, a slight increase over 1948.

Combined world-wide crude production of the 30 companies averaged 3,441,000 net barrels per day in 1949, a 10 percent decrease from 1948. The domestic operations of the group contributed 2,672,000 net barrels per day in 1949, which represented approximately 53.0 percent of the total production for the United States.

The volume of crude oil processed by the domestic and foreign refineries of the 30 oil companies averaged 5,240,000 barrels per day in 1949, a decrease of 1.8 percent from the quantity handled in 1948. The domestic refineries of the group ran 4,570,000 barrels per day to stills in 1949, which represented approximately 85.7 percent of the total throughput of all the refineries operating in the United States.

More Motor Vehicles Cause Sharp Gain in Tax Revenues

Governmental revenues from gasoline and automotive taxes are headed skyward—and with the speed of jet propulsion.

According to a Tax Economics Bulletin of the API, highway users are now providing more revenue to states through gasoline taxes and vehicle fees than was collected in 1940 by the federal government from personal and corporate income and profit taxes, which amounted to $2,125,000,000 10 years ago.

The annual yield from these state automotive levies was more than $2¼ billion in 1949, which compares with $1½ billion only 3 years earlier and slightly less than that immediately before World War II in 1941.

Gasoline taxes provide the bulk of this enormous revenue. Receipts from this source have shown substantial annual gains since the war, reaching a total of $1,466,247,000 in 1949. Last year's level of collections after refunds was 38 percent more than in 1946 and over 54 percent higher than 1941.

This greater tax yield is directly attributable to the large increases that have occurred in taxable fuel consumption, which grew from about 24 billion gallons in 1941 to approximately 33 billion gallons in 1949. The growth in motor fuel consumption in turn reflects the expansion of motor vehicle ownership since the war. The Bureau of Public Roads reported 44,120,243 private and commercial passenger cars, trucks, and buses registered in the U. S. in 1949, or 10 million more vehicles than in the year following the end of the war.

Completions

At All-Time Peak Rate

IS 1950 on its way to become the greatest drilling year in history, surpassing peak 1948? If the first 6 months' record can be counted on as a reliable yardstick, it is, for already slightly more than 20,000 new wells have been completed. In past years, wells completed in the first-half have always amounted to less than one-half of the year's totals, and if 1950 follows normal lines a new record is in the making.

Unless drilling restrictions develop from the current international difficulties or some other factor enters to prevent the industry from carrying on normally, a projection based on past performances indicates a new all-time high of at least 43,000 new wells. It possibly could be closer to 44,000; in either case, it would put the year in a class of its own for never have as many as 40,000 new wells been drilled in a single year. The present drilling record holder, 1948, came the closest by knocking on the door of this bracket with 39,477 new wells.

It should be pointed out that drilling rate projections can, at best, be indicative only of what may happen. A good example of their limitations can be taken from last year when the half-way mark found 1949 leading 1948 in total wells drilled, but lessened demand for domestic crude with attending price cuts on heavy oil and threatened drops on the lighter crudes exerted its pressure on industry's drilling and the final count left the 1948 high still on top.

Well Completions in the United States during June, 1950, and Cumulative for Year

(Figures compiled by WORLD OIL Staff from private reports and other sources as follows: Illinois from Illinois Geological Survey; Indiana from Indiana Division of Geology; Missouri from Missouri Geological Survey; Tennessee from Tennessee Division of Geology; Bradford, Kane-Clarendon and Allegany fields of Pennsylvania and New York from the *Producers Monthly*)

STATE or DISTRICT	MONTHLY COMPLETIONS, JUNE, 1950 — NEW WELLS: Oil	Dist.	Gas	Dry	Water Input	Gas Input	Water Disposal	Total New	Total Drilled Deeper	TOTAL COMPLETIONS: June, 1950	May, 1950	June, 1949	Footage June, 1950	CUMULATIVE TOTAL: Wells 1950	Wells 1949	Percent Diff.	Footage 1950	Footage 1949	Rigs in Operation (Drilling, Rigging Up and Shut Down): June 30, 1950	May 31, 1950	June 30, 1949
Alabama	3							3	1	4	5		15,263	19	6	+ 216.7	69,531	33,359	11	3	7
Arizona															3	— 100.0		7,766	5	4	7
Arkansas	19			12				31		31	37	37	107,879	186	151	+ 23.2	609,858	616,014	34	24	27
California	102		2	34				138	12	150	157	263	604,195	904	1,355	— 33.3	3,713,338	5,319,751	259	223	232
Colorado	1							1		1	3	4	5,793	19	28	— 32.1	66,815	118,739	17	12	20
Florida				2				2		2	1	1	14,701	9	9		59,087	57,731		1	3
Georgia				1				1		1			4,195	3	4	— 25.0	13,270	12,437			1
Idaho														3			8,540		3	3	
Illinois	129		2	141	1			273	1	274	251	253	621,390	1,174	1,110	+ 5.8	2,464,981	2,802,755	266	249	238
Indiana	52			87			2	141		141	149	97	259,677	678	531	+ 27.7	1,193,563	1,021,060	190	191	151
Kansas	180		33	119	1		3	336	1	337	408	262	1,064,236	1,825	1,364	+ 33.8	5,900,416	4,545,649	350	351	310
Kentucky	49		20	48				117		117	84	72	199,011	486	420	+ 15.7	885,993	764,592	113	108	85
Louisiana	129	13	10	56				208	3	211	206	215	1,164,637	1,180	988	+ 19.4	7,212,514	5,691,347	243	217	211
North Louisiana	79	2	9	33				123		123	107	137	397,997	610	524	+ 16.4	2,184,766	1,744,441	74	71	58
South Louisiana	50	11	1	23				85	3	88	99	78	766,640	570	464	+ 22.8	5,027,748	3,946,906	169	146	153
Maryland														1			3,612		2	2	
Michigan	26		1	30				57		57	93	81	123,678	383	450	— 14.9	900,539	1,013,035	154	140	120
Mississippi	8	3		16				27		27	29	34	171,140	180	177	+ 1.7	1,312,864	1,325,556	23	24	23
Missouri			1	1				2		2	3		629	22	7	+ 214.3	14,297	3,093	6	7	8
Montana	9		3	10				22		22	26	9	50,346	105	97	+ 8.2	283,126	278,445	32	29	64
Nebraska	1		1	7				9		9	7	2	36,891	37	2	+1750.0	150,020	7,109	9	3	3
Nevada																			1	1	
New Mexico	33		3	15				51	2	53	43	40	206,213	295	278	+ 6.1	1,309,036	1,183,574	103	75	93
New York	45				30			75		75	50	41	104,677	341	567	— 39.9	479,517	798,634	94	83	97
North Dakota																			1		1
Ohio	35		30	32				97	1	98	83	70	194,442	460	519	— 11.4	978,936	1,162,202	149	131	141
Oklahoma	274	1	12	138	1			426	13	439	532	392	1,508,506	2,596	2,059	+ 26.1	8,927,969	7,435,340	593	527	461
Oregon																			1	1	
Pennsylvania	57		27	7	55	8		154	1	155	133	145	271,890	763	1,082	— 29.5	1,383,407	1,908,970	260	251	239
South Dakota												1		1	1		5,710	2,825	1	2	2
Tennessee											2			3	14	— 78.6	3,993	14,376	9	9	6
Texas	899	15	54	409	7	2	2	1,388	25	1,413	1,479	1,283	6,112,880	8,104	6,994	+ 15.9	34,355,646	29,329,792	1,492	1,502	1,209
Dist. 1 S. Central	26	1		19			1	47	2	49	42	42	115,788	234	288	— 18 8	632,512	843,929	32	30	37
Dist. 2 Middle Gulf	45	1	6	17				69		69	71	61	397,158	316	331	— 4.5	1,823,759	1,947,139	62	61	35
Dist. 3 Upper Gulf	74	3	5	42			1	125	2	127	145	138	758,359	771	665	+ 15.9	4,445,859	4,106,218	144	137	123
Dist. 4 L. Gulf-S.W.	76	6	17	61				160	2	162	144	107	817,137	830	730	+ 13.7	3,977,169	3,588,027	117	130	95
Dist. 5 E. Central	5			11	6			22	1	23	23	11	65,750	98	117	— 16.2	391,838	561,984	25	23	16
Dist. 6 Northeast	34	1	2	7	1			45		45	85	80	209,588	311	483	+ 35.6	1,470,285	2,092,217	32	33	34
Dist. 7-B N. Central	94	2		69				165	4	169	159	186	457,409	935	961	— 2.7	2,648,560	2,925,585	133	132	177
Dist. 7-C W. Central	53	1	1	19				74	4	78	56	34	319,215	410	210	+ 95.2	1,701,694	1,018,559	93	85	50
Dist. 8 West	306			39				345	8	353	379	270	1,993,893	2,027	1,405	+ 44.3	11,016,589	6,927,846	526	532	377
Dist. 9 North	121		2	120		2		245	2	247	307	259	688,524	1,675	1,219	+ 37.4	4,683,986	3,402,642	224	224	153
Dist. 10. Panhandle	65		21	5				91		91	68	95	290,059	497	585	— 15.0	1,563,395	1,915,646	104	115	112
Utah				1				1		1	1	8	835	9	25	— 64.0	28,407	116,523	8	7	15
Virginia																			1	1	
Washington														2			16,032				
West Virginia	14		20	4				38	3	41	66	35	99,599	299	222	+ 34.7	732,706	648,993	255	284	224
Wyoming	23		1	20				44	1	45	50	47	201,809	266	294	— 9.5	1,309,887	1,386,389	75	53	99
Total U.S.	2,088	32	220	1,190	95	10	7	3,642	64	3,706	3,898	3,392	13,144,512	20,353	18,757	+ 8 5	74,393,610	67,606,059	4,760	4,518	4,097

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Looking Ahead

SHARPLY INCREASED sales of heating oil are indicated for next winter. Domestic oil burner sales during the first 5 months of 1950 were up 44 percent from the same period of 1949, indicating new installations this year will exceed 800,000 units unless war shortage of steel curtails manufacturing rate. Thus, the number of oil burners in use during the coming winter may be nearly 20 percent greater than ever before.

U. S. DRILLING during the first half of 1950 was at an all-time peak rate, 20,052 new wells having been completed. Since more wells normally are drilled in the last half of the year than in the first 6 months, statistical experience indicates more than 43,000 wells may be drilled this year provided war shortages do not curtail activity.

OIL FIELD EQUIPMENT sales, which have shown much improvement recently after lagging behind early postwar volumes during 1949, will perk up as war shortage fears spur buying. Some products, particularly tubular goods, will require long term deliveries.

OIL DEMAND by utility companies, which has been an important factor in petroleum's higher consumption rate this year, may taper off. Some utilities are switching back to coal, due to increased oil prices and fear of oil shortage in time of war.

AN OIL IMPORT BILL has little chance of passing Congress during its present session, despite coal and railroad interests having joined with independent oil operators in requesting such legislation. Even before the Korean war supplied the final kayo to import curtailment, about the only possibility left was for the measure to be tacked onto some other major legislation.

HEAVY CRUDE MARKETS are not likely to show much improvement for some time to come. Since natural gas sales and railroad dieselization are certain to continue to make inroads on the use of residual oil as a burning fuel, the future of heavy oil rests with its use as a raw material for the refinery production of gasoline and distillates. This will require large investments in cracking and coking equipment, which will be made slowly as long as there is plenty of light crude available to manufacture all the motor fuel and diesel oil needed.

PROSPECTS FOR FEDERAL QUIT-CLAIM TO TIDELANDS have been dimmed by Congressional preoccupation with present national emergency. House rules committee cleared a quit-claim bill for consideration on floor after favorable report by judiciary committee. But sponsors hesitate to ask for vote, though House in past twice approved similar bills, as measure likely would die for lack of Senate approval. Quit-claim advocates meanwhile are gloomy over speculation that President Truman may take advantage of war powers and assert sweeping control over tidelands in name of national defense.

FEDERAL POWER COMMISSION is moving toward regulation of independent producers and gatherers of natural gas, following Truman veto of Harris-Kerr bill that would have banned such regulations. It announced July 13 that after further study of independents' operations, it will promulgate regulations specifically applicable to them. At same time FPC rescinded its Order No. 139 of August 7, 1947, which gave assurance it would not assert control over producers and gatherers making only "arm's length" sales of gas.

Let the People Know:

International Trade is Vital to U. S. Oil Economy

An interview with

B. BREWSTER JENNINGS
President, Socony-Vacuum Oil Company

EDITOR'S NOTE: *This is the third in a series of interviews with petroleum industry leaders on important problems now involving oil around the world. In this article, B. Brewster Jennings, president of Socony-Vacuum Oil Company, expresses his views on the increasing difficulty of American business operations abroad. Jennings' 30 years' career in world trade aspects of the industry dates back to 1920, the year he was graduated from Yale University, and began as a clerk in the Marine department of Standard Oil Company of New York. Later he became purchasing agent and then manager of the Real Estate department. He transferred to Socony-Vacuum as assistant to the president, a position he held 15 years. On leave to the government from 1942 to 1944, Jennings directed tanker operations for the Maritime Commission and the War Shipping Administration, and was a member of the Petroleum Supply and Distribution Board. A month after his return to the company in 1944, he was elected president and executive committee chairman.*

Q. *What is your comment on the increasing difficulty which American business is encountering in operating abroad? Is there a likelihood that our American foreign business may be squeezed to extinction?*

A. The problems faced by American business abroad are largely political and economic. Though generalizing is dangerous, I think that by and large the political problems are not too serious and will be resolved in due course. The economic problems are much more serious. They boil down to the fact that people abroad do not sell enough goods and services to the United States to earn the money to buy from America the many things they want. Though this imbalance in international trade has been apparent for a quarter of a century or more, it has become very much accentuated since the end of World War II. Not many appreciate how much destruction of capital goods resulted from the war. That destruction created a huge demand for replacement of homes, railroad and highway bridges, docks, ships, and factories at a time when the productive capacity of Europe was at a minimum. In short, European countries had to increase their imports and at the same time export less. I am enough of an optimist to believe that because the nature of this economic problem is generally well understood, and because corrective forces are being generated, the situation in international trade is likely to improve. Certainly I do not believe that American enterprises abroad are going to be squeezed out entirely, though they will have considerable difficulty for some years.

Q. *What is the significance of our American business abroad?*

A. American business abroad is from every point of view beneficial, both to the U. S. and to other countries. If we stop to think about it, that must be so. If it were not, foreign commerce would not exist. As I see it these are the principal benefits:

(a) Our international trade benefits those countries with which we deal. Only through such trade can the benefits of one country's goods or know-how be brought to others. Living standards abroad would be very much lower right now were it not for the shipment of goods and skills which America has been making all these years.

(b) International trade benefits our own economy. International trade is no more a one-way street than is domestic trade. We in the U. S. gain through enjoyment of many things we get from abroad and could not get here. And prices of some of our manufactured goods are lower than would be possible without the volume based on sales abroad as well as at home. Some industries depend on both imports and exports.

(c) Our foreign business strengthens our good-neighbor policy. A hermit is not a good neighbor, and, come to think of it, the hermit in our domestic society is quite analogous

B. BREWSTER JENNINGS

to the commercial isolationist in an international society.

(d) National defense is also strengthened by foreign trade. Unless a country is completely self-sufficient in every resource and in manpower, participation in international commerce is not only desirable but essential to that country's security.

Q. *What are the possible solutions to the problem of restriction of our foreign business—should it be more ECA funds, trade agreements, barter arrangements, or what?*

A. Though the balance of payments problem is simple in its fundamentals, its solution involves extraordinary complexities. My own view is that we should not attempt a complete answer at once but rather should foster the things that will tend to correct the imbalance. Certainly in one way or another the U. S. will buy more of what Europe has to offer that compares favorably in price and quality with what we make ourselves. And Europe must improve its productive capacity, become more self-sufficient and gradually reduce her dependency on imports from the U. S. The ECA, bi-lateral trade agreements and barter deals are not any of them long-range cures. They have their places, temporarily, as stop-gaps but they can never do the job.

Q. *What stake has the petroleum industry in all this?*

A. The American oil industry has a very large stake in this situation. Over the years some $3 billion have been invested abroad by American oil companies and the current volume of the international oil trade of America is 2 million barrels daily. All this investment has been made and business developed without any subsidy or help from our government other than the usual support given by our State Department to any American operating abroad. Petroleum, because it is such a marvellous source of energy, and indigenous to so few countries, is the largest single item in international trade. Even during the war, when huge volumes of munitions and other supplies were used, oil made up over half of all the overseas shipments of the Allied forces.

There has been a good deal of publicity as to the large number of dollars required for ECA oil transactions. Actually the sums involved have been no more than one might expect in a trade constituting so large a proportion of international commerce.

Our country's stake in foreign oil operations is great and may be vital, quite apart from the interests of privately owned American business. Because of the strategic value of our foreign oil in time of war, and the possibility that some day those holdings may be a source of essential low-cost fuel for our domestic economy, it is very definitely in the national interest that American-owned foreign oil concessions and businesses be retained and function as going concerns.

Satisfactory Half Year Results From

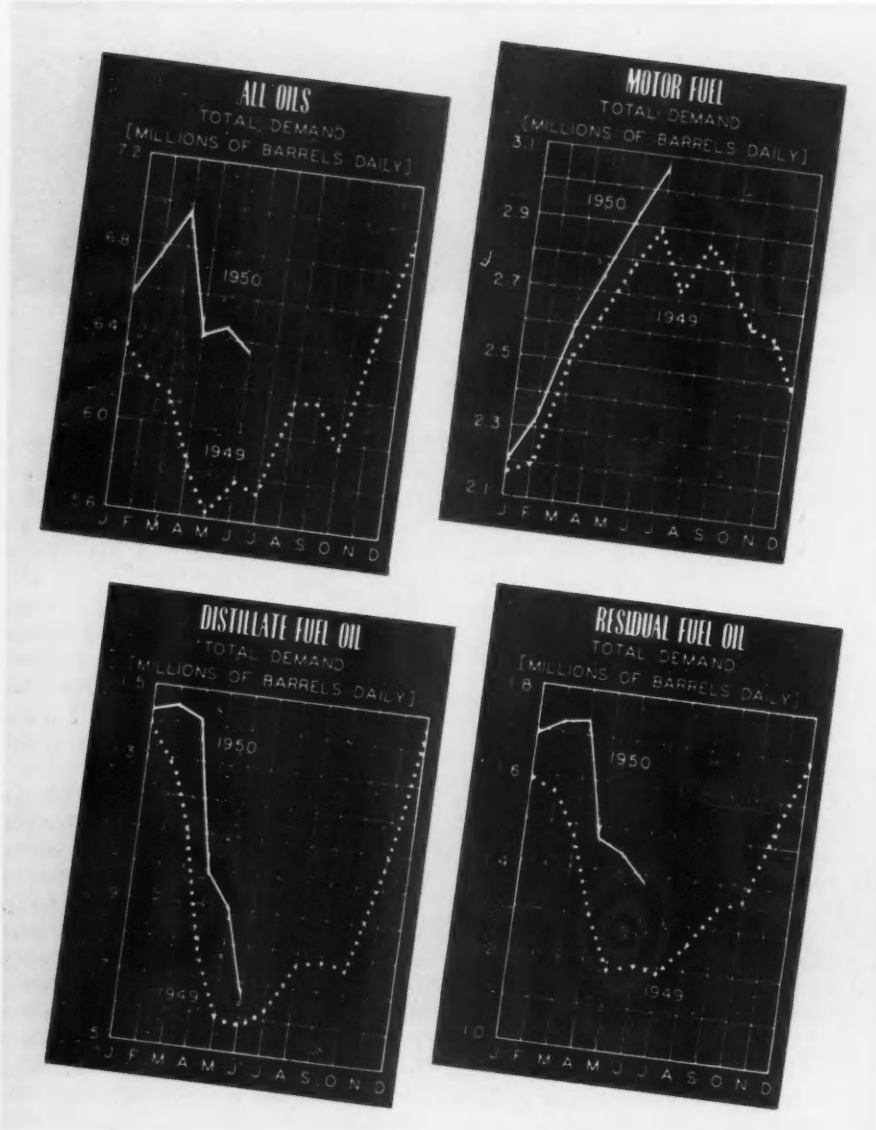
By L. J. LOGAN, Associate Editor

DURING the first half of 1950 the petroleum industry operated on an especially satisfactory basis, after having successfully carried out in 1949 a curtailment of supply to recognize lower demand for fuel oils and to liquidate surplus stocks.

In 1949 the demand for petroleum products (except gasoline) consistently failed to equal the 1948 record. But as 1950 began, the curves were above 1948, and they have continued through mid-year to run above 1948, establishing new all-time high trends.

For the first half of 1950, total demand for all oils averaged approximately 6,578,000 barrels per day, up 10 percent from 1949 and substantially exceeding the 6,168,000 barrels per day of the first half of 1948.

These gains have occurred in spite of lower exports. Total exports averaged 278,000 barrels daily in the first 6 months of 1950, compared with 357,000 daily in the like months of 1949 and 359,000 daily in the similar period of 1948. Domestic demand at 6,300,000 barrels daily in this year's first half was 12 percent above the 5,625,000 daily of 1949's initial half and compared with 5,809,000 daily in the like period of 1948.



Curves for motor fuel demand have reflected steady and gradually increasing consumption as the number of motor vehicles in use has continued to rise. The curve for 1949 was above that for 1948 and the one for 1950 has been above 1949. In the first half of 1950, motor fuel demand averaged approximately 2,651,000 barrels daily, up 4.8 percent from the 2,529,000 daily in first half of 1949 and comparing with 2,366,000 daily in first half 1948. Motor fuel exports averaged 72,000 barrels per day in first 6 months of 1950, down 45 percent from the 129,000 daily in 1949 and comparing with 95,000 daily in 1948's first half. Domestic consumption of motor fuel averaged about 2,579,000 barrels daily for January-June, 1950, up 7.5 percent from 2,400,000 daily in like period of 1949 and comparing with 2,271,000 daily in same months of 1948. Motor fuel stocks at mid-year 1950 were equivalent to 43 days' supply, at rate of demand in the first 6 months of the year, compared with 45 days' supply at mid-year 1949 and 43 days' at mid-year 1948. Yield of gasoline from crude has been stepped up to 43.4 percent this year from 43.3 last year and 39.5 percent in first half of 1948.

Distillate fuel oil demand of 1,136,000 barrels daily in first half 1950 was 19 percent above the 954,000 daily a year previously and somewhat above the 1,078,000 daily of the initial half of 1948. Exports of 31,000 daily compared with 41,000 in 1949 and 64,000 in 1948. Domestic demand of 1,105,000 daily was 21 percent above the 913,000 daily of 1949 and also above the 1,014,000 daily of 1948's first 6 months. Distillate stocks at mid-year 1950 represented 47 days' supply, compared with 68 days' supply at middle of 1949 and 43 days' supply at mid-1948. Distillate yield from crude was back up to 18.5 percent in 1950 from 17.0 percent in 1949; it had been 18.9 percent in 1948.

Residual fuel oil demand averaged about 1,573,000 barrels daily in the initial half of 1950, up 14 percent from the 1,382,000 daily of 1949 and also exceeding the 1,475,000 daily of first half 1948. Exports of 39,000 barrels daily were a

Peak Demand

little above both 1949 and 1948. Domestic demand of 1,534,000 daily was 14 percent above the 1,346,000 daily of 1949 and exceeded the 1,446,000 daily of 1948. Stocks of residual fuel oil were reduced in unusual volume in the first half of 1950, as were inventories of distillate fuel oil. Residual stocks at mid-year 1950 were equivalent to only 26 days' supply, compared with 47 days' supply held at middle of 1949 and 30 days' supply on hand at mid-1948. Yield of residual from crude was down further to 20.6 percent in 1950 from 22.6 percent in 1949 and 23.6 percent in first half of 1948.

Demand for lubricants averaged about 130,000 barrels daily in the first 6 months this year, up 5.7 percent from the 123,000 daily last year but under the 139,000 daily of 1948. These changes reflect domestic fluctuations mostly, as exports have been about the same as in 1949 and 1948. Lube yield of 2.3 percent from crude in 1950 is same as in 1949 but less than the 2.6 percent of 1948. Mid-year stocks are 67 days' supply, against 81 a year ago and 59 two years ago.

While demand was setting new records in the first half of this year, it was supplied to the extent of 267,000 barrels daily by withdrawals from crude and products storage. Crude stocks were drawn down at rates averaging 69,000 barrels daily and refined products by nearly 200,000 daily. In contrast, there had been additions to stocks in the first 6 months averaging 160,000 barrels daily in 1949 and 127,000 daily in 1948. Total stocks of all oils at end of June 1950 were 554,777,000 barrels, equivalent to 84 days' supply on basis of demand in the first 6 months of the year. The 634,711,000 barrels of stocks at mid-year 1949 were equal to 106 days' supply. The 523,906,000 barrels held at mid-year 1948 were 85 days' supply, about the same as the present 84 days' supply.

Imports of 806,000 barrels daily in the first half of 1950 compared with 585,000 daily in first half 1949 and 476,000 daily in 1948. Crude imports of 462,000 daily compared with 411,000 in 1949 and 304,000 in 1948. Refined product imports of 344,000 daily compared with 174,000 in 1949 and 172,000 in 1948.

Because of drawing on stocks and importing increased volumes, record demand for oils in this year's first half did not result in record rates of domestic crude production or crude runs to stills, although a new high was set for production of natural gasoline (472,000 daily against 412,000 in 1949 and 389,000 in 1948). Total crude runs to stills averaged 5,414,000 barrels per day, up 1.6 percent from the 5,330,000 daily last year but less than the 5,493,000 daily in 1948. Refinery runs of domestic crude averaged 4,949,000 daily compared with 4,923,000 in 1949 and 5,200,000 daily in 1948. Runs of foreign crude were 465,000 daily, against 407,000 in 1949.

Crude runs of 5,643,000 barrels daily in June 1950 were equivalent to 84.0 percent of the record plant capacity of 6,716,000 barrels daily available at mid-year 1950. In June of 1949 runs of 5,162,000 daily were 81.4 percent of the then existing capacity of 6,340,000 daily. In June 1948, refinery runs of 5,632,000 barrels daily were equivalent to 96.5 percent of 5,838,000 barrels capacity. At mid-year 1950 the industry was relatively well situated from the standpoint of reserve refining capacity, which amounted to over 1 million barrels daily.

With stocks being reduced, imports up, and natural gasoline output higher, domestic production of crude oil was held down to 5,032,000 barrels daily in the first half of 1950, a decrease of 2.2 percent from the 5,144,000 daily in January-June 1949 and comparing with 5,429,000 daily in 1948. During June 1950, U. S. crude production averaged 5,343,000 barrels daily, and output was up to almost 5,500,000 daily at the middle of July. It is due to be further increased

■ CONTINUED ON PAGE 70

(also see Table Page 62)

Stocks of Crude Petroleum in U. S. by Grades, at End of June

(Based on Weekly Reports of U. S. Bureau of Mines)

(THOUSANDS OF BARRELS)

Grade or Origin	July 2, 1949	July 1, 1950
Pennsylvania Grade	3,048	2,884
Other Appalachian	1,965	1,578
Lima-Michigan	1,116	813
Illinois-Indiana	13,240	8,021
Arkansas	3,022	3,071
Kansas	8,969	8,226
Louisiana	14,999	15,536
Northern Louisiana	3,384	3,765
Gulf Coast	11,615	11,771
Mississippi	3,178	2,176
New Mexico	7,642	5,894
Oklahoma	31,183	25,899
Texas	129,249	112,399
East Texas	18,272	15,787
West Texas	51,568	41,952
Gulf Coast	30,150	27,221
Other Texas	29,259	27,439
Panhandle	5,460	3,994
North	7,067	7,617
South	7,045	6,902
Other	9,687	8,926
Rocky Mountain	13,907	12,646
California	34,651	35,495
Foreign	8,144	6,305
Total in United States	274,313	240,943

Stocks of Major Petroleum Products Held by Refining Companies in the United States at End of June, Compared with 1949

Stocks at refineries, at bulk terminals, in transit, and in pipe lines. Data from Bureau of Mines except June, 1950, from weekly reports of American Petroleum Institute

(THOUSANDS OF BARRELS)

DISTRICT	FINISHED AND UNFINISHED GASOLINE Stocks End of June		KEROSINE Stocks End of June		GASOIL AND DISTILLATE FUEL Stocks End of June		RESIDUAL FUEL OIL Stocks End of June	
	1949	1950	1949	1950	1949	1950	1949	1950
East Coast	26,785	25,985	8,790	7,173	21,026	13,655	9,692	10,253
Appalachian	3,656	3,283	565	502	905	784	633	541
District No. 1	2,483	2,377	412	384	705	595	387	344
District No. 2	1,173	906	153	118	200	189	246	197
Indiana, Illinois, Kentucky	25,178	22,791	4,056	3,975	10,208	7,955	5,258	3,436
Oklahoma, Kansas, Missouri	11,143	12,152	1,438	1,081	4,830	4,841	2,176	1,238
Texas Inland	4,166	3,343	498	466	856	1,160	1,194	713
Texas Gulf Coast	15,273	16,598	3,703	3,331	9,844	8,068	7,330	4,099
Louisiana Gulf Coast	5,700	5,540	2,007	2,786	4,167	3,323	2,017	1,883
North Louisiana and Arkansas	2,435	2,660	462	391	957	493	266	197
Rocky Mountain	3,288	4,789	334	408	1,514	1,408	859	679
District No. 3	62	106	28	25	88	61	27	37
District No. 4	3,226	4,683	306	383	1,426	1,347	832	642
Total East of California	97,624	97,141	22,853	20,113	54,307	41,687	29,425	23,039
California	16,417	17,126	795	964	10,423	11,254	35,203	17,610
Total United States	114,041	114,267	23,648	21,077	64,730	52,941	64,628	40,649

Demand for and Supply of All Oils, Crude Oil, Motor Fuel, Kerosine, Fuel Oil, and Lubricants

Sources: U. S. Bureau of Mines except May and June, 1950, estimated with aid of API Reports

(THOUSANDS OF BARRELS)

ITEM	First Half, 1949	First Half, 1950	Percent Change
ALL OILS			
Domestic Production, Total	1,005,792	996,326	— 0.9
(Daily Average)	5,557	5,505	— 0.9
Crude Petroleum	931,144	910,866	— 2.2
(Daily Average)	5,144	5,032	— 2.2
Natural Gasoline	74,582	85,350	+ 14.4
(Daily Average)	412	471	+ 14.4
Benzol	66	110	+ 66.7
(Daily Average)	1	1	+ 66.7
Imports, Total	105,971	145,867	+ 37.6
(Daily Average)	585	806	+ 37.6
Crude Petroleum	74,322	83,650	+ 12.6
(Daily Average)	411	462	+ 12.6
Refined Products	31,649	62,217	+ 96.6
(Daily Average)	174	344	+ 96.6
Changes in Stocks, All Oils	+28,968	—48,342	.....
(Daily Average)	+160	—267	.....
Stocks, Beginning of Period	605,743	603,119	— 0.4
Crude Oil	256,627	253,356	— 1.3
Refined Products	343,537	342,932	— 0.2
Natural Gasoline	5,579	6,831	+ 22.4
Stocks, End of Period	634,711	554,777	— 12.6
(Days' Supply)	106	85	— 19.8
Crude Oil	274,691	240,943	— 12.3
Refined Products	352,989	305,934	— 13.3
Natural Gasoline	7,031	7,900	+ 12.4
Demand, Total	1,082,795	1,190,535	+ 10.0
(Daily Average)	5,982	6,578	+ 10.0
Exports, Total	64,596	50,326	— 22.1
(Daily Average)	357	278	— 22.1
Crude Petroleum, Total	15,533	14,547	— 6.3
(Daily Average)	86	80	— 6.3
Refined Products, Total	49,063	35,779	— 27.1
(Daily Average)	271	198	— 27.1
Domestic Demand, Total	1,018,199	1,140,209	+ 12.0
(Daily Average)	5,625	6,300	+ 12.0
CRUDE PETROLEUM			
Supply:			
Domestic Production, Total	931,144	910,866	— 2.2
(Daily Average)	5,144	5,032	— 2.2
Imports, Total	74,322	83,644	+ 12.5
(Daily Average)	411	462	+ 12.5
Change in Stocks	+18,064	—12,413	.....
(Daily Average)	+100	—68	.....
Stocks, Beginning of Period	256,627	253,356	— 1.3
Stocks, End of Period	274,691	240,943	— 12.3
(Days' Supply)	50	44	+ 12.0
Supply, Total	987,402	1,006,923	+ 2.0
(Daily Average)	5,455	5,563	+ 2.0
Demand			
Runs to Stills, Total	964,791	979,913	+ 1.6
(Daily Average)	5,330	5,414	+ 1.6
Domestic Crude	891,126	895,817	+ 0.5
(Daily Average)	4,923	4,949	+ 0.5
Foreign Crude	73,665	84,096	+ 14.2
(Daily Average)	407	465	+ 14.2
Exports, Total	15,533	14,547	— 6.3
(Daily Average)	86	80	— 6.3
Transfers to Fuel Oil Stocks	4,131	3,456	— 16.3
(Daily Average)	23	19	— 16.3
Distillate Fuel Oil	1,443	1,118	— 22.5
Residual Fuel Oil	2,688	2,338	— 13.0
Used as Fuel, and Losses	2,947	9,007	+205.6
(Daily Average)	16	50	+205.6
Demand, Total	987,402	1,006,923	+ 2.0
(Daily Average)	5,455	5,563	+ 2.0
KEROSINE			
Production, Total	50,543	57,862	+ 14.5
(Daily Average)	279	320	+ 14.5
Percent Yield from Crude	5.2	5.9	.....
Imports, Total	.....	245	.....
(Daily Average)	.....	1	.....
Change in Stocks	—247	+189	.....
(Daily Average)	—1	+1	.....
Stocks, Beginning of Period	23,895	20,888	— 12.6
Stocks, End of Period	23,648	21,077	— 10.9
(Days' Supply)	84	66	— 21.4
Demand, Total	50,790	57,918	+ 14.0
(Daily Average)	280	320	+ 14.0
Exports, Total	1,654	878	— 46.9
(Daily Average)	9	5	— 46.9
Domestic Demand	49,136	57,040	+ 16.1
(Daily Average)	271	315	+ 16.1

ITEM	First Half, 1949	First Half, 1950	Percent Change
MOTOR FUEL			
Production, Total	469,863	483,343	+ 2.9
(Daily Average)	2,596	2,670	+ 2.9
Refinery Gasoline, Total	417,458	426,183	+ 2.1
(Daily Average)	2,306	2,355	+ 2.1
(Yield from Crude)	43.3	43.4	.....
Natural Gasoline, etc.	74,582	85,350	+ 14.4
(Daily Average)	412	472	+ 14.4
Less sales of L.P.G.	21,042	26,857	+ 27.6
Less Transfers Cycle Prods.	1,201	1,443	+ 20.1
Benzol	66	110	+ 66.7
Imports, Total	.....	2	.....
(Daily Average)	.....	.....	.....
Change in Stocks	+12,039	+3,562	.....
(Daily Average)	+67	+19	.....
Stocks, Beginning of Period	101,060	110,417	+ 9.3
Finish Gasoline	95,481	103,586	+ 8.5
Natural Gasoline	5,579	6,831	+ 22.4
Stocks, End of Period	113,099	113,979	+ 0.8
(Days' Supply)	45	43	— 4.4
Finish Gasoline	106,068	106,079	.....
Natural Gasoline	7,031	,900	+ 12.4
Demand, Total	457,824	479,783	+ 4.8
(Daily Average)	2,529	2,651	+ 4.8
Exports, Total	23,450	12,940	— 44.8
(Daily Average)	129	72	— 44.8
Domestic Demand	434,374	466,843	+ 7.5
(Daily Average)	2,400	2.579	+ 7.5
DISTILLATE OIL FUEL			
Production, Total	163,746	181,755	+ 11.0
(Daily Average)	905	1,004	+ 11.0
Percent Yield from Crude	17.0	18.5	.....
Transfers from Crude	1,443	1,118	— 22.5
(Daily Average)	8	6	— 22.5
Imports, Total	675	397	— 41.2
(Daily Average)	4	2	— 41.2
Change in Stocks	—6,745	—22,494	.....
(Daily Average)	—37	—124	.....
Stocks, Beginning of Period	71,475	75,435	+ 5.5
Stocks, End of Period	64,730	52,941	— 18.2
(Days' Supply)	68	47	— 30.9
Demand, Total	172,609	205,764	+ 19.2
(Daily Average)	954	1,136	+ 19.2
Exports, Total	7,377	5,654	— 23.4
(Daily Average)	41	31	— 23.4
Domestic Demand	165,232	200,110	+ 11.1
(Daily Average)	913	1,105	+ 11.1
RESIDUAL FUEL OIL			
Production, Total	217,811	202,492	— 7.0
(Daily Average)	1,203	1,118	— 7.0
Percent Yield from Crude	22.6	20.6	.....
Transfers from Crude	2,688	2,338	— 13.0
(Daily Average)	15	13	— 13.0
Imports, Total	30,232	60,412	+ 99.8
(Daily Average)	167	334	+ 99.8
Change in Stocks	+607	—19,544	.....
(Daily Average)	+3	—108	.....
Stocks, Beginning of Period	64,021	60,193	— 6.0
Stocks, End of Period	64,628	40,649	— 37.1
(Days' Supply)	47	26	— 44.7
Demand, Total	250,124	284,786	+ 13.9
(Daily Average)	1,382	1,573	+ 13.9
Exports, Total	6,432	7,060	+ 9.8
(Daily Average)	36	39	+ 9.8
Domestic Demand	243,692	277,726	+ 14.0
(Daily Average)	1,346	1,534	+ 14.0
LUBRICANTS			
Production, Total	22,396	23,069	+ 3.0
(Daily Average)	124	127	+ 3.0
Percent Yield from Crude	2.3	2.3	.....
Imports, Total	.....	.....	.....
(Daily Average)	.....	.....	.....
Change in Stocks	+79	—519	.....
(Daily Average)	+1	—3	.....
Stocks, Beginning of Period	9,843	9,219	— 6.3
Stocks, End of Period	9,922	8,700	— 12.3
(Days' Supply)	81	67	— 17.3
Demand, Total	22,317	23,588	+ 5.7
(Daily Average)	123	130	+ 5.7
Exports, Total	6,701	6,753	+ 0.8
(Daily Average)	37	37	+ 0.8
Domestic Demand	15,616	16,835	+ 7.8
(Daily Average)	86	93	+ 7.8

Expanding Markets Increase Value of Natural Gas Reserves

NATURAL GAS DISCOVERIES, production, and reserves have become much more important than formerly, as extensive new pipe line systems are opening up large markets for natural gas, while the plants being built for recovery of liquids from gas also make natural gas supplies desirable.

Natural gas prices at the well should tend to improve as more pipe lines and gas processing plants seek contracts for the gas production.

(Since this article was written, the Harris-Kerr bill was vetoed. It would have exempted independent producers and gatherers from Federal Power Commission regulation. Many regard the veto as a serious blow to gas conservation and to further expansion of the natural gas industry.)

By KEITH W. JOHNSON

Industrial Economist, Federal Reserve Bank of Dallas

OF GREAT significance to oil and gas companies, particularly those that operate in the Southwest, is the vast expansion of the market for natural gas now being achieved through construction of extensive new natural gas pipe line systems.

In view of this rapidly expanding market for natural gas, much greater importance than formerly is attached to the discovery and development of natural gas reservoirs and the conservation of established reserves.

Also making natural gas reserves more desirable are the plants being built for recovery of petroleum liquids from natural gas.

Prices of natural gas at the well should tend to improve as more pipe line companies and gas processing plants seek contracts with producers for gas supplies.

All these developments, which have been greatly stepped up in the postwar period, should make natural gas reserves increasingly valuable and desirable to find and develop.

Through the current expansion of pipe line systems and markets, natural gas will contribute increasingly to the American standard of living and to the industrial development of the nation, particularly in the Southwest. This ideal fuel will be increasingly used because of its cleanliness, the high temperatures obtainable, the ready control of its flow and rate of burning, the lack of need for storage, and its cheapness compared to most other fuels. As a raw material, natural gas is a source of helium, carbon black, natural gasoline, butane, propane, kerosine, and numerous chemical and other products.

While the conservation of natural gas received virtually no attention during the early years of the industry, it now is recognized as being tremendously important. Formerly, an apparent excess of reserves, plus production far in excess of consumption, resulted in a low market value for gas, and hence, little effort to preserve it for future use. Because much of the gas was produced as a by-product of oil field activity, with casing-head gas flowing out along with the crude oil, the production and frequently the excessive waste of natural gas tended to be somewhat unplanned results of oil production. Thus, it was considered less feasible to cut gas output to the level of consumption than simply to release the surplus gas into the atmosphere or to flare the gas. The great distances from some gas-producing fields to large potential markets made it more difficult to put the gas to practical use.

The practice of wasting gas was encouraged further by the misconception that the presence of gas necessarily interfered with the recovery of oil. Waste of gas as well as oil also occurred when producers attempted to get as much of the oil or gas as they could before an adjoining producer might drain the common underlying pool. Another cause of the loss of gas was the blowing of wells to remove water, sand, and debris and to test their open-flow capacities. Additional sources of waste are leaks in pipe

lines, inefficient burning of gas, and the use of high-quality sweet gas rather than sour gas in making carbon black.

Recent Trends Encouraging

As a result largely of economic and technical factors, recent developments have been more encouraging of conservation. The building of an ever-wider network of pipe lines has provided a profitable market and higher price at the well for gas that once would have been wasted as a valueless substance. This proved an economic incentive to the conservation of gas still within the ground. A very large investment in pipe lines and facilities for the transmission and distribution of natural gas, as well as in appliances, equipment, and plants, has been premised upon the continued availability of natural gas; and this heavy investment has greatly strengthened the economic incentive to conservation. Furthermore, the increasing interest in obtaining a maximum recovery of petroleum has led to greater knowledge of the significance of natural gas in the maintenance of oil field pressures, with the result that the gas is less often released or flared and is more often retained in or returned to the underground formations.

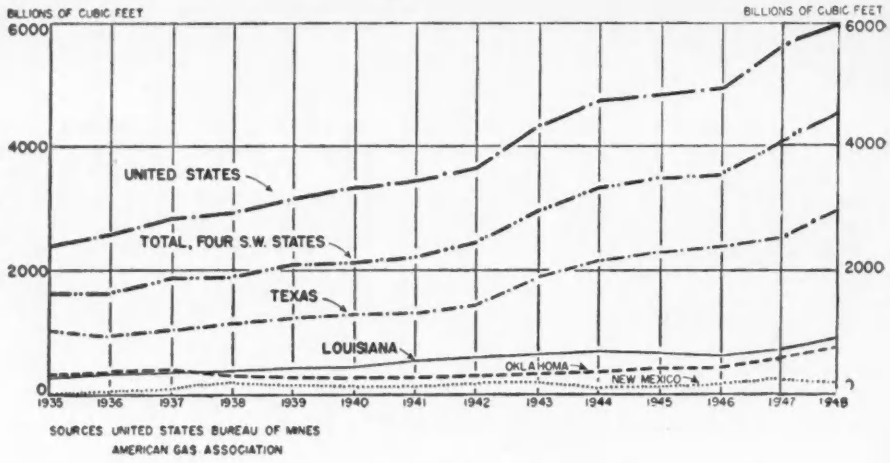
In recent years the process of extracting natural gasoline and other valuable liquids from wet natural gas has added to the value of the original gas and thus created more incentive for its conservation. An additional force making for conservation has been the unitization movement, by which the output of an oil or gas field may be regulated with a view to maximum ultimate recovery. Such unitization prevents producers from wasting oil and gas underlying the wells of other producers in the same field. In the long-run, economic incentives seem likely to lead to increasingly effective conservation efforts.

The growth in natural gas production has been linked closely with the expansion of the petroleum industry. The underground reservoirs of crude petroleum contain varying amounts of natural gas, which are recovered simultaneously with the production of crude petroleum. The amount of gas in a reservoir may influence considerably the cost of producing crude petroleum and, also, may partially determine the amount of crude oil ultimately to be recovered from a specific reservoir. Moreover, since the geological formations of reservoirs of crude petroleum and of natural gas are similar, drilling for oil of course often leads to the discovery of gas.

Technological improvements in methods of drilling wells and in pipeline transportation have been developed chiefly by the petroleum industry, but they have been made available almost simultaneously to the gas industry. The development of petroleum reservoir engineering, which has increased the attention being given to the importance of natural gas in the ultimate recovery of oil, has emphasized the need for the conservation of gas and for the maintenance of gas pressures in underground oil reservoirs. At the same time, research has yielded increasingly efficient processes for extracting the natural gas liquids from the wet gas produced chiefly as a by-product of crude production.

Such research not only has made possible the rapid increase in production of these natural gas liquids to meet the expanding demands for petroleum products but also has led to extension of the practice of returning the dry gas to the underground reservoirs as a means of maintaining pressure. Thus, the growth of the gas industry has been and will continue to be dependent in a large measure upon the petroleum industry. At the same time, it should be recognized that with the increasing uses of, and the expanding markets for, natural gas and its derivatives, the natural gas industry is gradually acquiring a more independent status. Indeed, it already ranks as a major industry.

Although gas production has risen almost continuously, estimated proved reserves of natural gas have increased to many times earlier levels. The newly discovered reserves almost every year have exceeded considerably the total utilization for the year. Hence, it is apparent that presently known reserves only partially indicate future gas supplies. Not only have proved reserves been increasing, but an ever larger pro-



Natural gas production, 1935-1948, excluding amounts returned to formation.

TABLE 1

Estimates of Proved Recoverable Reserves of Natural Gas in the United States, 1925-1949

(IN TRILLIONS OF CUBIC FEET)

End of Year	Estimate of Reserves
1925	23.0
1930	46.0
1934	62.0
1937	66.0
1938	70.0
1940	85.0
1941	113.8
1942	110.0
1943	110.0
1944	133.5
1945	147.8
1946	160.6
1947	165.9
1948	173.9
1949	180.4

Sources: Petroleum Administration for War. American Gas Association.

TABLE 2

Production and Reserves of Natural Gas in U. S. by States

(MILLIONS OF CUBIC FEET)

STATE	Net Production in 1949	Reserves at End of 1949
Arkansas	59,185	874,190
California	543,488	9,991,635
Colorado	24,828	1,227,095
Illinois	40,130	233,192
Indiana	6,250	25,200
Kansas	323,283	14,089,560
Kentucky	90,000	1,349,397
Louisiana	805,726	26,687,811
Michigan	17,438	214,911
Mississippi	68,950	2,528,969
Montana	37,925	803,471
New Mexico	256,706	6,241,003
New York	3,700	66,685
Ohio	47,000	652,571
Oklahoma	567,335	11,625,979
Pennsylvania	70,000	621,680
Texas	3,023,714	99,170,403
Utah	6,313	65,577
West Virginia	180,000	1,715,233
Wyoming	72,339	2,173,677
Miscellaneous	731	23,105
United States	6,245,041	180,381,344

Source: American Gas Association.

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portion of the reserves is being found in the Southwest. The once dominant Northeast now has only 1 percent of the nation's total gas reserves, as compared to 80 percent in the Southwest. No less than 55 percent of the nation's reserves are in Texas, with Louisiana having 14 percent, Oklahoma 7 percent, and New Mexico 4 percent. The Southeast has 4 percent, the Midwest 8 percent, and the Mountain and Far West region 7 percent. (See Figure 1 and Tables 1 and 2.)

Reserve Estimates

Despite the tremendous amounts of natural gas reserves which have been discovered, they are very small in relation to reserves of other mineral fuels, measured in terms of heat equivalents. In the U. S. the estimated proved reserves of natural gas amount to only 0.2 percent of the reserves of all mineral fuels; and in the Southwest, where natural gas is particularly important, only 4.6 percent. In the latter area other mineral fuels account for the following percentages of total reserves: coal 72.1 percent, lignite 19.8 percent, crude oil 3 percent, and natural gas liquids 0.5 percent. While natural gas reserves in the Southwest appear sufficiently large to meet requirements for a considerable period in the future, the rapid expansion of production and consumption emphasizes the desirability of maintaining a high rate of current discovery and of conserving existing supplies.

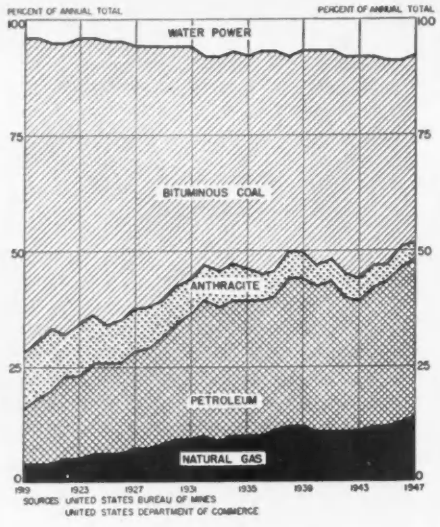


FIGURE 2. Distribution of total energy consumption in the U. S., 1919-1947.

Widespread Market

The greatest increases in natural gas reserves and in production have occurred in the Southwest, but the potential market is the whole country. This situation is important to the industry because the capacity to produce natural gas in the Southwest far exceeds the present consumption capacity of the area. In recent years, the large populations of major cities, particularly in the Midwestern and eastern portions of the country, have provided outlets for increasing amounts of gas, and this demand is expected to continue to increase.

The low cost of natural gas and the increasing assurance of reserves sufficient for at least several decades have been important economic factors in the spread of natural gas pipe line networks. The rapid growth of the natural gas industry during the 1920's also was facilitated by the introduction of ditch-digging machinery and electrically welded, seamless pipe. Such developments permitted the industry to change from a regional to a national basis. Since 1931, nearly 60,000 miles of long-distance natural gas pipe lines have been laid. In 1947, the changeover of the wartime Big Inch and Little Inch petroleum pipe lines to natural gas transmission initiated a postwar period of rapid expansion. Longer and larger pipe lines have been constructed or authorized, some of them 31 inches in diameter. Practically all such large pipe lines originate in the Southwest and terminate in large consuming centers from coast to coast.

Pipe Line Construction

A new all-time high of about 8500 miles of new natural gas pipe lines were built in 1949. This brought the total mileage of such lines in the U. S. to about 268,000, or 14 percent more than the total railroad mileage of the nation and about 74 percent more than the total oil pipe line mileage. The above pipe line figures do not include the many miles of local distribution systems. Expenditures on pipe lines in 1948 totaled $650 million, and industry sources predict about $1,950 million additional expenditures during the four years 1949-52. (A more recent survey on natural gas industry expansion is cited on page 48.)

During the period 1919-40, while the consumption of coal was slowly declining, the consumption of natural gas and petroleum products followed a generally upward trend, a trend which was accelerated during the war and postwar periods. The consumption of anthracite coal, which is utilized largely for residential heating, has fallen off gradually but steadily as the use of fuel oil and gas has increased. The decline in bituminous coal consumption reflects the growing efficiency of its industrial utilization, as well as the inroads of water power as a source of electrical energy and of oil and natural gas as fuels. (See Figure 2.)

Natural gas has enjoyed a favorable

TABLE 3

Gas Sales of Utilities by Class of Service and Type of Gas, 1949

(In billions of cubic feet)

Class of Service	Natural Gas	Manufactured Gas	Mixed Gas	Liquefied Petroleum Gas	Total Gas
Residential	913.1	290.2	83.9	6.8	1,294.0
Commercial	299.0	72.0	21.1	3.0	395.1
Industrial	1,756.9	65.5	31.6	0.6	1,854.6
Other	106.3	4.5	1.0	*	111.8
Total	3,075.3	432.2	137.6	10.4	3,655.5

*Less than 0.1.

Source: American Gas Association.

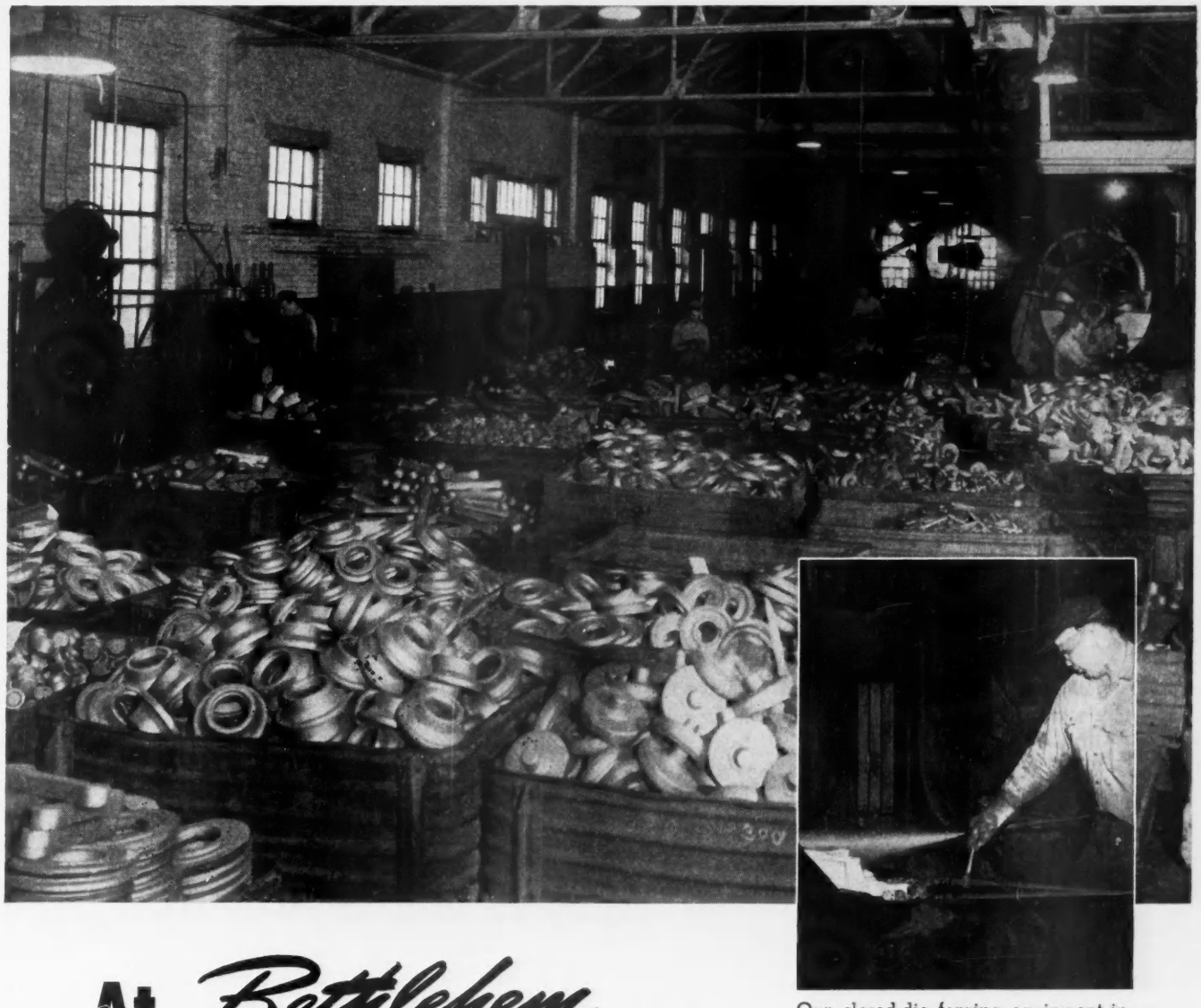
TABLE 4

Industrial Consumption of Natural Gas in the United States by Type of Industry, 1935-47

(In billions of cubic feet)

YEAR	Field Use	Carbon Black Plants	Petroleum Refineries	Portland Cement Plants	Electric Public Utility Power Plants	Other	Total
1935	580	242	80	27	125	442	1,496
1936	618	283	93	37	156	517	1,706
1937	651	341	113	40	171	597	1,914
1938	659	325	110	37	170	511	1,812
1939	681	347	98	40	191	607	1,964
1940	712	369	128	42	183	643	2,076
1941	686	365	148	54	205	759	2,218
1942	721	336	202	65	239	801	2,363
1943	781	316	244	52	306	972	2,669
1944	855	356	315	36	360	992	2,914
1945	917	432	338	38	326	1,011	3,063
1946	898	478	332	58	307	1,038	3,110
1947	934	485	364	60	373	1,123	3,339

NOTE: Includes some mixed gas and gas from both utility and non-utility sources.
Sources: United States Bureau of Mines. Federal Power Commission.



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About the Author

KEITH W. JOHNSON, Industrial Economist of the Federal Reserve Bank of Dallas, joined the bank's Research department in 1948. He graduated from the University of Kansas, took graduate work at Cornell University, and received his Master's and Doctor's degrees from Duke University. He has been an economist with the Department of Commerce, the War Production Board, and the Combined Raw Materials Board. Before joining the bank, he was Assistant Professor of Economics and Business Administration at the University of New Mexico.

postwar price position as compared to coal and oil. This has stimulated the consumption of the former, particularly by industrial users. A group of electric utilities using coal found that their fuel costs per thousand kilowatt-hours rose 71 percent from 1939 to 1947, while unit fuel costs decreased 9 percent for a group of utilities using natural gas. Since 1932, bituminous coal prices have moved irregularly upward under the impact of rising labor costs. Anthracite prices were somewhat depressed by the loss of part of the residential heating market to other fuels, but the war stimulated a price rise for that fuel. Petroleum prices increased but little during the 1930's due to the discovery and rapid development of large new fields, which added to supplies and exerted a depressing influence upon prices. While price control had the effect of moderating advances in petroleum prices during the war, the advances in the postwar period . . . brought about by the large demand in relation to supply . . . resulted in a price level in 1948 about double that in 1929. Gas, on the other hand, has been increasing steadily in availability, due to the opening of new fields and the extension of pipe lines. Hence, gas prices declined moderately from 1932 to the end of the war and increased only slightly thereafter.

The price advantage enjoyed by natural gas, as well as its greater availability, has resulted in a most striking increase in consumption. Its share in the total energy consumed in the nation rose from 4.3 percent in 1919 to 13.7 percent in 1947. Furthermore, natural gas sales are expected by 1952 to exceed 1947 levels by more than one-half, according to a forecast by the National Security Resources Board. This relative and absolute increase in the use of natural gas has been largely at the expense of anthracite and bituminous coal. However, much of the increased natural gas consumption has been due to its expansion into new areas and its introduction to new uses. Petroleum products and water power have risen in importance as energy sources at rates only a little less rapid than that noted for natural gas. In addition to natural gas, manufactured gas (made from coal, coke, oil, or tar) and mixed natural and manufactured gas have been used in increasing quantities, particularly in the Northeast; but the lower heat content and frequently higher costs of such gases have limited their use generally to those ever smaller areas where sufficient supplies of natural gas are not available.

The increase in demand for natural gas has reflected generally higher incomes and the expansion of industrial facilities using gas as a fuel or raw material. Much recent industrial expansion has occurred in the Southwest, where natural gas is readily available. Of the total U. S. consumption of natural gas in 1949, about 57 percent was for industrial purposes, 30 percent for residential purposes, 10 percent for commercial purposes, and 3 percent for governmental and other uses. (See Table 3.)

Residential customers to the number of over 12 million were being served by natural gas utilities at end of the year, 1949. This was more than 1 million above the level of the previous year and about 5 million above 1939. The amount of gas consumed by residential customers about doubled during the last decade. This rapid increase was due mainly to the installation of more gas-using equipment and appliances, such as furnaces, space heaters, water heaters, and gas refrigerators. The Gas Appliance Manufacturers' Association estimates that domestic gas appliances in use for central heating numbered 2,300,000 at the end of 1947, or almost double the figure for the end of 1940.

Although there has been more general use of gas, the consumption of manufactured gas has not kept pace with that of natural gas. The number of users of manufactured gas was relatively stable during 1949 but remained about 1 million above the 1939 level. At present, the number of residential users of natural gas exceeds the number using manufactured gas by over 4 million whereas at the end of 1939 approximately 2 million more customers were using manufactured gas than were using the natural product. Moreover, the average residential consumer of natural gas uses nearly twice as much gas as the consumer of other types of gas, mainly because of the lower price of the natural product. With the expansion of transmission facilities for natural gas and with rising costs for the coal required in the making of manufactured gas, some gas utilities have shifted from manufactured to natural gas or mixtured gas.

Industrial Applications

Industrial uses of natural gas are many and varied. In 1945, among large manufacturing consumers of natural gas, space heating and boiler fuel accounted for 34.9 percent of the total consumption of natural gas by these concerns, gas engine fuel 3.5 percent, heat treatment or processing 39.4 percent, raw material uses 19.8 percent, and other uses 2.4 percent. The chemical and carbon black industries account for most of the use of natural gas as a raw material, while the majority of its use as gas engine fuel is by the chemical and petroleum refining industries.

Use of natural gas in heat treating or processing is important in many different industries, for example, the manufacturing of cement, in which powdered

TABLE 5

Representative Chemicals Made From Natural Gas

Chemicals	Raw Materials	Used In
Ethylene glycol	Natural gas, water	Permanent type antifreeze
Propylene glycol	Natural gas, water	Lipstick, lotions, extracts, foods, tobacco moistener
Dipropylene glycol	Natural gas, water	Hydraulic brake fluid
Triethylene glycol	Natural gas, water	Air germicide
Ethylene dibromide	Natural gas, sea water	Ethyl gasoline
Methyl chloride	Natural gas, salt	Household refrigerators
Methylene chloride	Natural gas, salt	Paint remover
Chloroform	Natural gas, salt	Anesthetic
Carbon tetrachloride	Natural gas, salt	Dry-cleaning fluid
Perchloroethylene	Natural gas, salt	Metal cleaning
Hydrochloric acid	Natural gas, salt	Treating oil wells
Vinyl chloride	Natural gas, salt	Plastics, seat covers
Ethylene dichloride	Natural gas, salt	Insecticide
Toluene	Natural gas, coal	T.N.T. explosive
Styrene	Natural gas, coal	Synthetic rubber, plastics

Source: The Dow Chemical Company.

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limestone or oyster shells and clay or shale are burnt; brick, tile, and pottery making, in which kiln drying is an essential step; the glass industry, in which sand, soda ash, lime, and other ingredients are melted and fused; the iron and steel and other metal and metal-working industries, in which gas may supply the heat for melting or softening metals during various stages of production; petroleum refining, in which cheap and abundant gas is often used to supply the heat for distillation and cracking processes; and the chemical, bone black, and lamp and carbon black industries, in which gas may serve as a source of heat as well as a raw material. (See Table 4.)

Aside from oil and gas field use, carbon black plants are the largest industrial users of natural gas, and consumption by this industry has doubled since 1935. About two-thirds of the U. S. carbon black production is in West Texas, while nine-tenths is in the Southwest. This industry requires large volumes of very cheap gas, ordinarily gas not tapped by a transmission pipe line that might make accessible a more lucrative market. The meeting of this requirement tends to coincide with another, namely, distance from large populations, which would find objectionable the smoke produced during the flaring of the gas to make the soot or carbon black. The sour gas of northwest Texas, due to its undesirable sulphur content, has only a limited use other than as a raw material for carbon black production.

Carbon black is used chiefly by the rubber industry to increase the resiliency, wear-resistance, and surface-gripping qualities of automobile, truck and airplane tires. The upward trend in rubber consumption and the wartime introduction of synthetic rubbers requiring a greater proportion of carbon black have contributed to the expansion of carbon black production. Carbon black has a few other but much less important uses, chiefly as a black pigment for paint and ink.

The petroleum refining industry is the second largest industrial consumer of natural gas. Consumption of natural gas by this industry is now more than four times the 1935 figure. This is partly due to the greater availability of the gas in the refinery areas and the rising market price of petroleum as compared to gas, but is also due to the rapid increase in the extraction of natural gasoline from natural gas. The removal of certain volatile liquids, mainly natural gasoline, does not appreciably affect the suitability of the gas for fuel purposes but does provide a liquid which, when blended with refinery gasoline, increases the volatility and octane rating of the final gasoline product. Hence, large volumes of gas are first made to yield natural gasoline before being used as fuel or being pumped or recycled back into the gas or oil field formations to maintain or rebuild reservoir pressures.

In oil fields this recycling process assures greater ultimate recovery of the oil. Natural gasoline plants are located near the source of the gas from which their products are extracted. Such proximity is virtually a necessity, since the wet gas used is less easily piped than dry gas due to the tendency of the gaseous liquids to condense under pressure or at low temperatures. When the gas is recycled back to the underground reservoirs, location of plants near the source of the gas is doubly desirable. As a result of these locational factors, 76 percent of the nation's natural gasoline output was in the Southwest in 1949, with Texas alone accounting for 49 percent.

The chemical industry's use of natural gas was stimulated greatly by the war, particularly in the Southwest. A considerable variety of chemical products is now produced in southwestern plants from natural gas and natural gas liquids in combination with water, sea water, salt, or coal. The dry gas remaining after the extraction of chemical raw materials is used as fuel. Thus, chemical production does not necessarily decrease the total availability of natural gas for fuel purposes. (See Table 5.)

Peak Demand

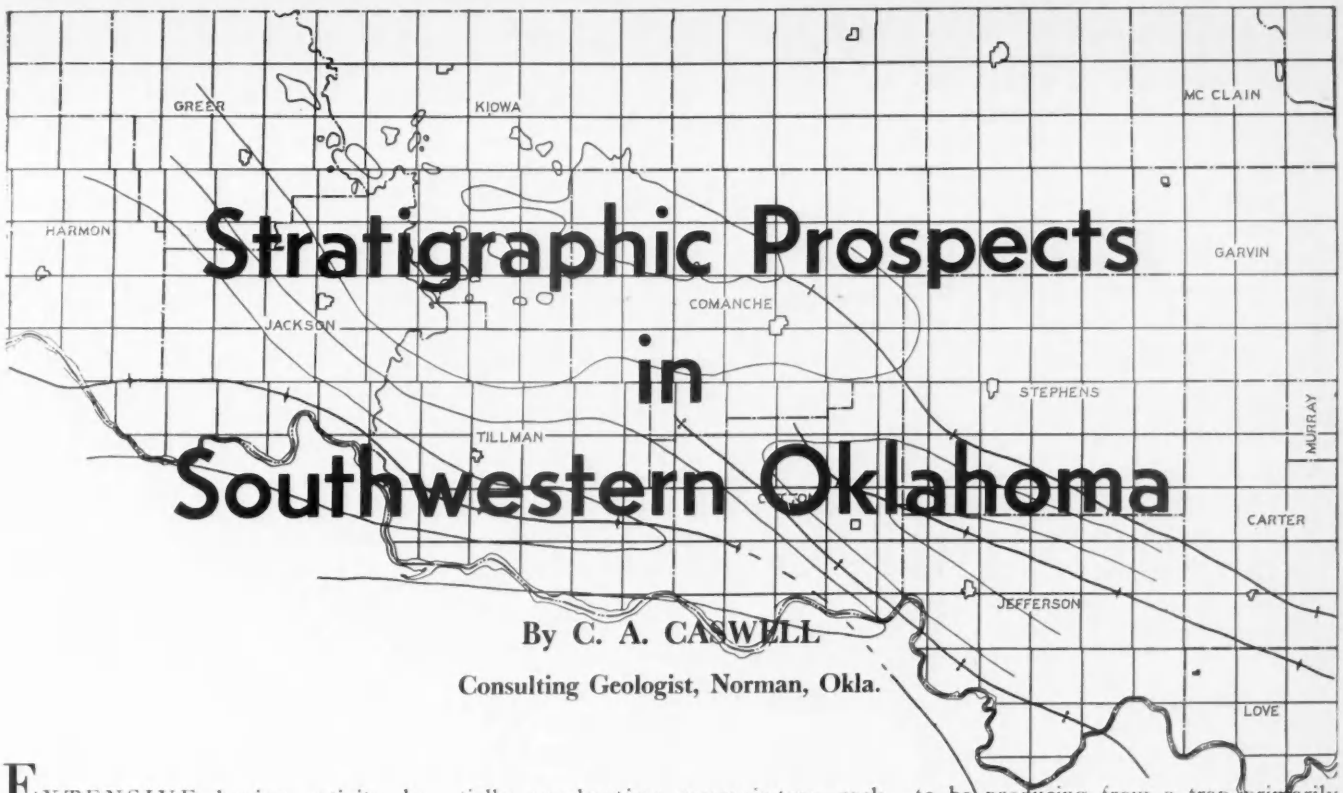
CONTINUED FROM PAGE 61

over 100,000 barrels under August allowables and will then be around 5,600,000 barrels per day, or close to the all time record month of 5,688,000 daily in December 1948.

Even at the prospective August rate of 5,600,000 barrels daily, U. S. crude production would be, however, at least 600,000 barrels a day under the rate at which domestic crude could be produced without damage to reservoirs. The indicated maximum efficient rate for the U. S. is at least 6,200,000 barrels per day. Texas alone had producing ability in excess of 3 million barrels daily last March, according to a Texas Railroad Commission engineer, and some additional capacity doubtless has been subsequently developed in Texas, and in August, that state will be producing only about 2,475,000 barrels daily and will have unused reserve capacity of over 525,000 barrels daily. The National Petroleum Council's committee on reserve producing ability last spring estimated U. S. ability to produce without waste around 6,000,000 barrels daily of crude and 500,000 daily of natural gasoline and condensate. That report evidently was quite conservative.

U. S. Crude Runs to Stills and Percent of Refinery Capacity Used, by Districts, June and First 6 Months, 1949, 1950
Runs from Bureau of Mines, except May and June, 1950, from American Petroleum Institute. Capacities from American Petroleum Institute.
(THOUSANDS OF BARRELS)

REFINING DISTRICT	CRUDE RUNS IN JUNE: Total Amount Run			CRUDE RUNS IN JUNE: Daily Average Run		REFINING CAPACITY IN USE, JUNE: Daily Capacity		REFINING CAPACITY IN USE, JUNE: Percent Capacity Used		TOTAL AMOUNT OF CRUDE RUN TO STILLS FIRST SIX MONTHS		
	June, 1949	June, 1950	% Diff. 49-50	June, 1949	June, 1650	June, 1949	June, 1950	June, 1949	June, 1950	Jan.-June, 1949	Jan.-June, 1950	% Diff. 49-50
East Coast	20,830	27,813	+ 33.5	694	927	891	1,006	77.9	92.1	137,528	156,569	+ 13.8
Appalachian	4,439	4,827	+ 8.7	148	161	193	191	76.7	84.3	28,300	29,114	+ 2.9
District No. 1	2,700	2,704	+ 0.1	90	90	118	117	76.3	76.9	16,629	16,525	— 0.6
District No. 2	1,739	2,123	+ 22.1	58	71	75	74	77.3	95.9	11.671	12,589	+ 7.9
Indiana, Illinois, Kentucky	25,942	31,420	+ 21.1	865	1,047	1,080	1,171	80.1	89.4	162,673	180,859	+ 11.2
Oklahoma, Kansas, Missouri	12,710	14,625	+ 15.1	424	488	500	557	84.8	87.6	76,119	82,198	+ 8.0
Texas Inland	6,511	6,353	— 2.4	217	212	296	286	73.3	74.1	40,300	36,834	— 8.6
Texas Gulf Coast	37,079	35,352	— 4.7	1,236	1,178	1,559	1,592	79.3	74.0	233,717	214,790	— 8.1
Louisiana Gulf Coast	12,029	13,624	+ 13.3	401	454	458	474	87.6	95.8	76,646	81,111	+ 5.8
North Louisiana and Arkansas	2,268	1,968	— 13.2	76	66	96	86	79.2	76.7	13,541	12,435	— 8.2
Rocky Mountain	5,432	6,195	+ 14.0	180	206	213	252	84.5	81.7	30,572	33,468	+ 9.5
District No. 3	317	397	+ 25.2	10	13	15	17	66.7	76.5	2,102	2,393	+ 13.8
District No. 4	5,115	5,798	+ 13.4	170	193	198	235	85.9	82.1	28,470	31,075	+ 9.1
California	27,621	27,086	— 1.9	921	903	1,054	1,101	87.4	82.0	165,395	152,535	— 7.8
Total United States	154,861	169,263	+ 9.3	5,162	5,643	6,340	6,716	81.4	84.0	964,791	979,913	+ 1.6



Stratigraphic Prospects in Southwestern Oklahoma

By C. A. CASWELL

Consulting Geologist, Norman, Okla.

EXTENSIVE leasing activity by major companies and independents in recent months has demonstrated wide interest in stratigraphic trap possibilities in southwestern Oklahoma. This article is an attempt to explain the geologic significance of some of the recent developments in this area insofar as the attractive possibilities of stratigraphic-type traps are concerned.

Although it is true that some of the leasing has been done on purely structural considerations, the greatest amount of acreage acquired in this area has been taken on the realization of the more extensive stratigraphic type prospects. For this reason, and since the exploration techniques for structural traps is more widely understood in this area, this paper has been restricted to consideration of stratigraphic possibilities.

A stratigraphic trap has been defined as one in which a variation in the stratigraphy is the chief confining element in the reservor which traps the oil and gas.

This implies that any consideration of stratigraphic trap possibilities in an area must be concerned, first of all, with satisfying three basic requirements. These are as follows:

1. The presence of possibly productive horizons in the stratigraphic section of the area.
2. The presence of lateral variations of the lithologic characteristics of the stratigraphic section present.
3. The relation of the stratigraphic section and its geologic history to the major structural features of the region.

That is to say, a stratigraphic trap possibility may exist in a region whenever it can be established that a potentially productive reservoir-type rock layer loses its lateral continuity by reason of (1) lateral lithologic variations due to changing conditions of original deposition and/or subsequent diagenesis; or (2) the characteristics of the relationship of the potentially productive horizon to the major structural features of the region as established by the diastrophic history of the region.

Therefore, we may assume that if a region can be shown to contain, in many places, the above outlined conditions, the discovery of commercial oil fields that will produce from stratigraphic type traps may be anticipated. And a study of the general geologic conditions that exist along the southwest flank of the Wichita Mountain system of Oklahoma indicates that here such stratigraphic possibilities are present; although, up to the present, the old Walters field in the north central part of Cotton County, Oklahoma, is the only important field that can be shown to be producing from a trap primarily controlled by stratigraphic factors.

SOUTHWESTERN OKLAHOMA is attracting considerable interest among companies and operators seeking new reserves in the Mid-Continent. Many recognize its important potentialities provided stratigraphy can be properly interpreted. Because of the Arbuckle orogeny, it is believed that many stratigraphic type pools will be discovered. Some already have been found. The drilling involved is fairly shallow.

In this area the cross-section (Figure 1) illustrates the geologic relationships that indicate the possibility of future production from stratigraphic traps. This picture is fairly typical of conditions on the southwest flank of the Wichita Mountains around the north end of the Marietta Syncline.

An analysis of this geologic picture indicates four things of major importance that infer the existence of stratigraphic traps associated with them.

1. The presence of a prominent zone of facies change from porous sands to non-porous limy sands and limestones occurring in the Cisco-Hoxbar-Canyon section of the Marietta syncline. This development takes place in an updip direction from south to north as the axis of the Wichita Mountain system is approached.

2. The numerous converging unconformities, both major and minor, in the geologic section. Unconformities, which as they converge toward the mountain axis, produce loss of section by reason of onlap, truncation, and wedgeout conditions within the Cisco-Hoxbar-Canyon section and the Arbuckle section.

3. The presence of onlap of the Pennsylvanian system onto the Arbuckle toward the axis of the mountains.

4. The existence of a hiatus of considerable magnitude between the base of the Canyon and the top of the Arbuckle. A hiatus, or mission section, that shows the absence of a considerable portion of the standard geologic section for the region.

The facies change from sands to limes

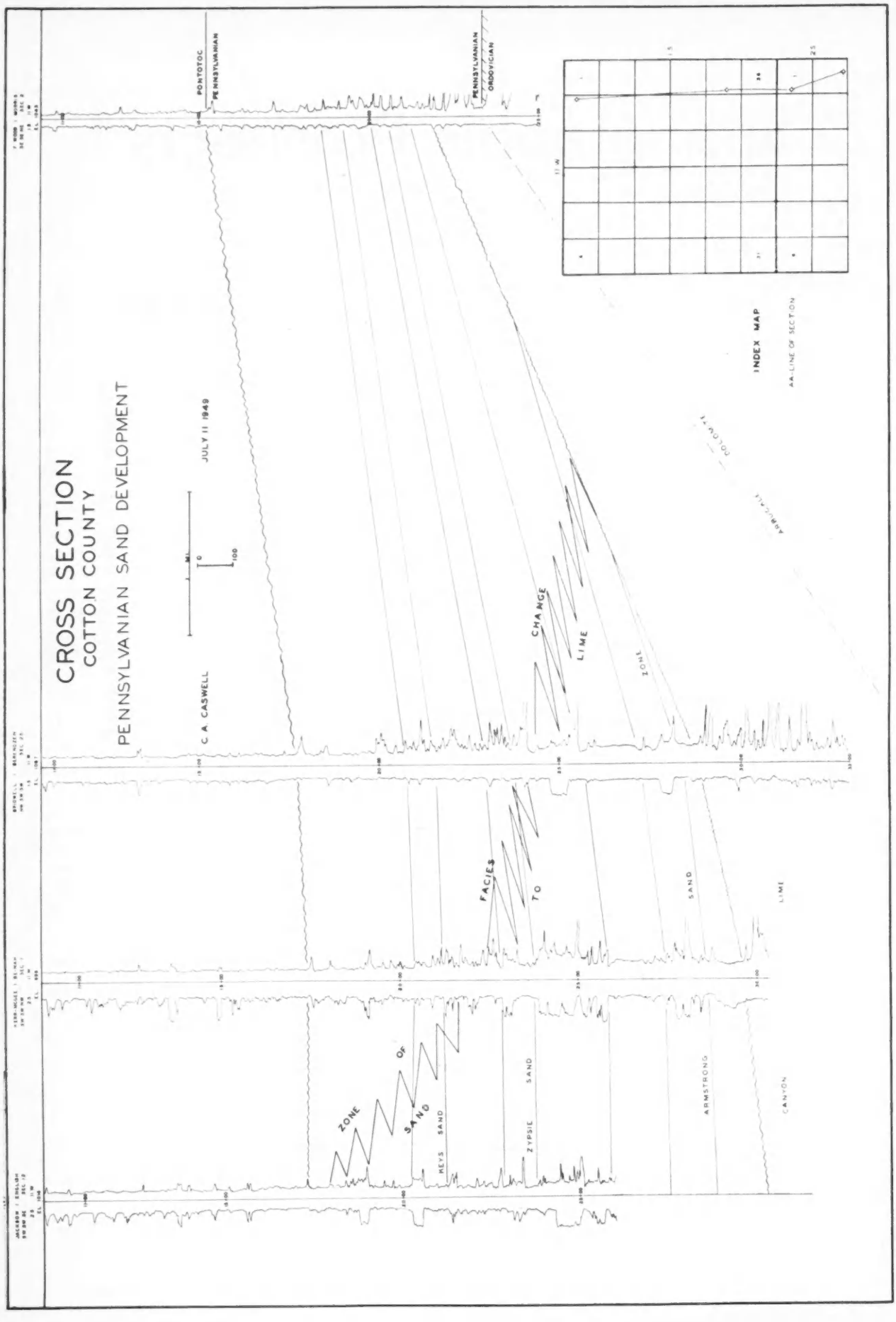

CROSS SECTION
COTTON COUNTY
PENNSYLVANIAN SAND DEVELOPMENT
JULY 11 1949
C. A. CASWELL
PONTOTOC
PENNSYLVANIAN
PENNSYLVANIAN
ORDOVICIAN
INDEX MAP
A-A LINE OF SECTION
CHANGE
LIME
FACIES
TO
SAND
LIME
ZONE
OF
SAND
KEYS SAND
ZYPSIE SAND
ARMSTRONG
CANYON

FIGURE 1

illustrated in this cross-section (Figure 1) is the feature primarily responsible for the accumulation of oil in the Walters field mentioned previously. While there may be minor structural anomalies in the vicinity, these are of secondary importance in the formation of the trap from which this field produces. And other traps, as yet undiscovered, should have been created in this area by this prominent facies change.

The presence of onlap of the Pennsylvanian System upon the Arbuckle Formation shown in this cross-section is of great regional importance in the consideration of stratigraphic trap possibilities of the region. And this condition, as will be shown, exists not only here in the Marietta Syncline, but all along the southwest flank of the Wichita Mountains.

However it should be pointed out that onlap on a more minor scale is also important within the Pennsylvanian System. This is shown by the relationship of the Armstrong sand zone to the Canyon lime in the cross-section. Here is a case of a minor unconformity within the Pennsylvanian which produces conditions of possible trap.

The relationship of the Pennsylvanian System to the Ordovician and the magnitude of the hiatus present in this cross section indicates the importance of another factor in the consideration of stratigraphic trap possibilities in this region. This factor is the element of truncation of formations below the Pennsylvanian.

Although it is highly probable that parts of the missing section indicated in the hiatus shown on this cross section were never deposited in southwestern Oklahoma, it is equally probable that some of these older beds are present in the deeper parts of both the Marietta Syncline and the Hollis, or Palo Duro,

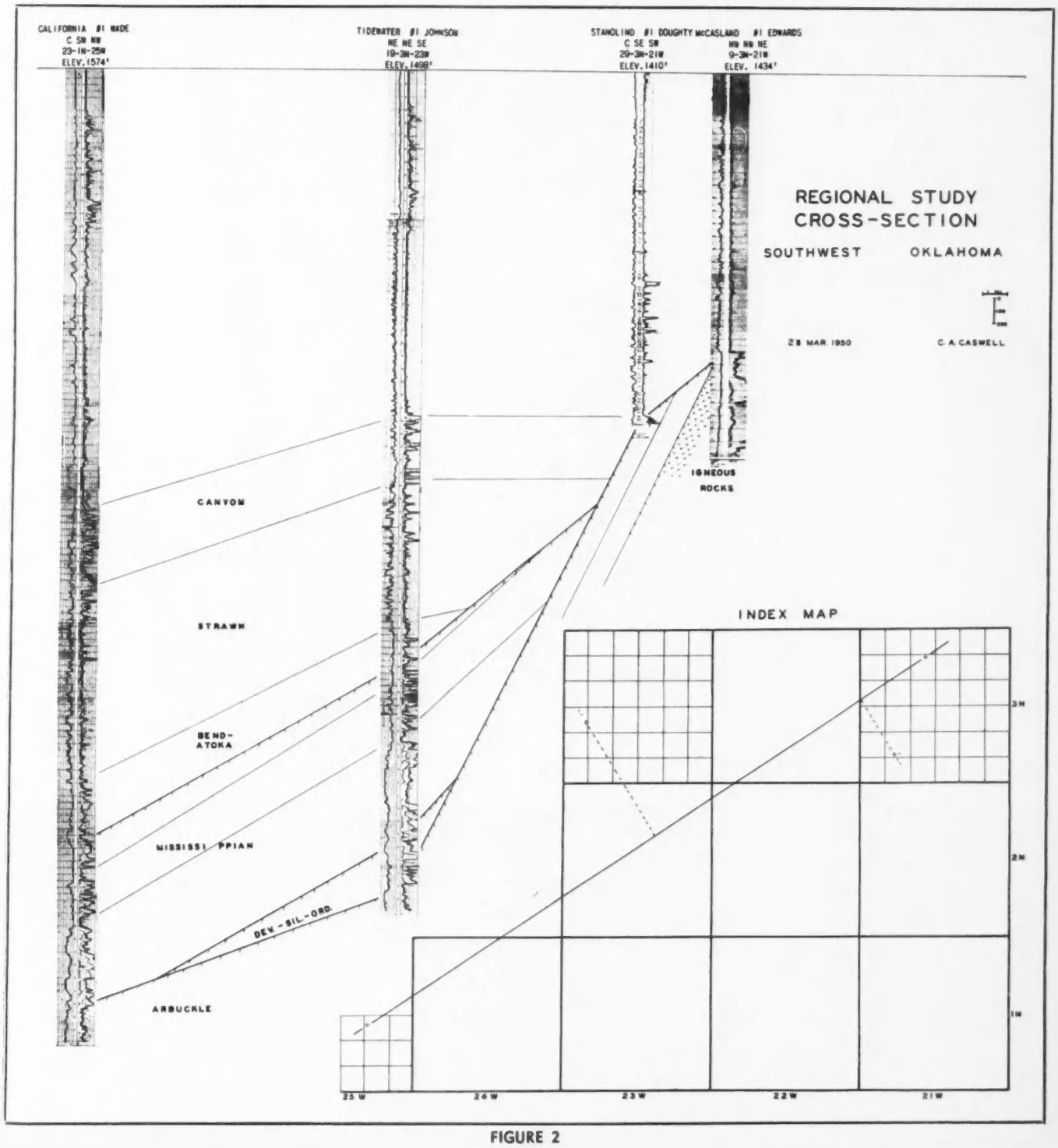


FIGURE 2

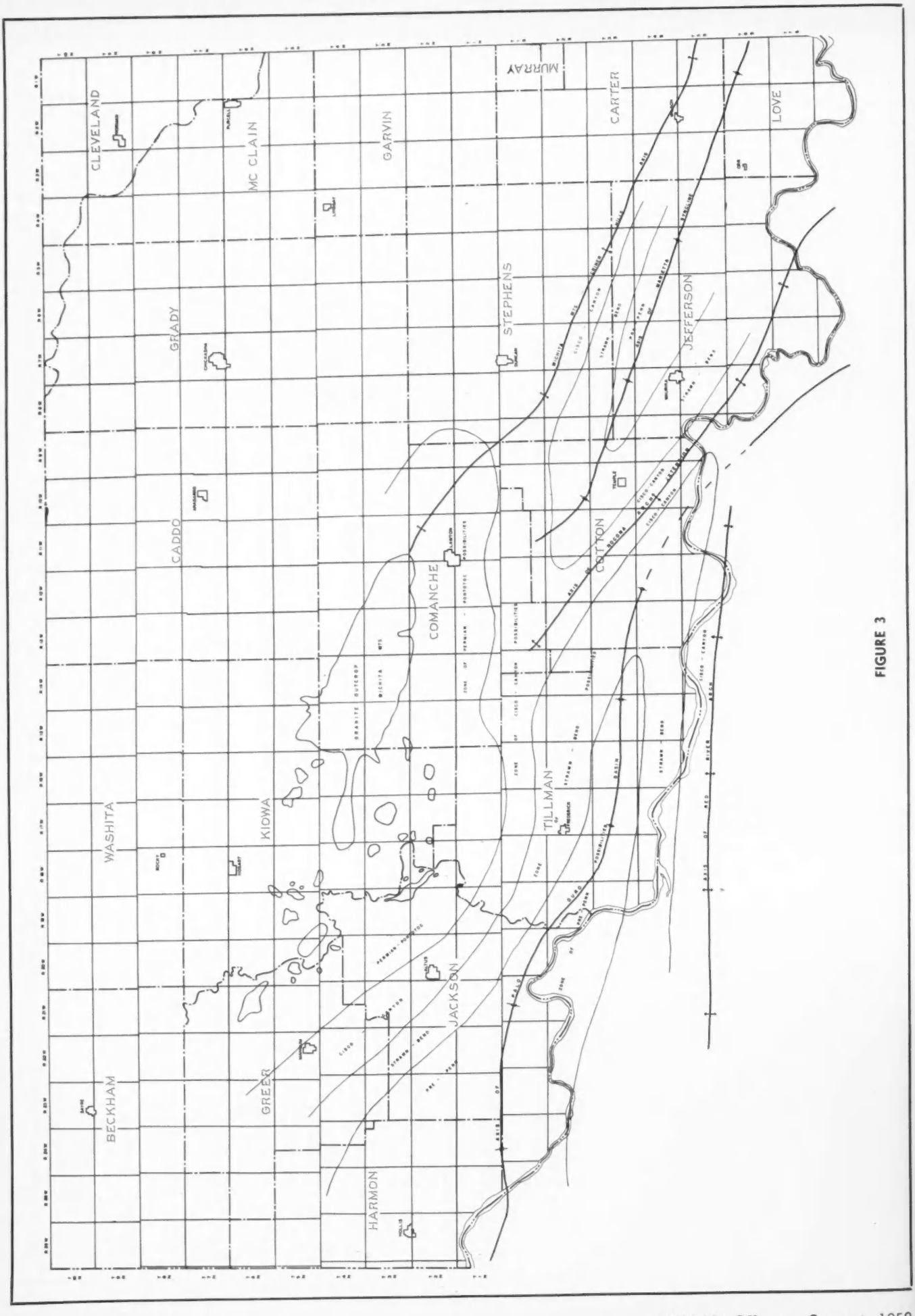

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FIGURE 3

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Basin. There is definite evidence for this conclusion from deeper wells drilled at points nearer to the axis of the basin features.

This evidence indicates that the axis of the Wichita Mountains, and minor related structural features in the region, will be flanked with belts of successively lower Pennsylvanian stratigraphic prospects created by onlap and belts of pre-Pennsylvanian prospects resulting from truncation. However, at present, there has not been sufficient deep drilling in the basin areas to delineate fully the outlines of the belts of pre-Pennsylvanian truncation.

The increasing importance of the factor of truncation as the lower formations in the geologic column are approached is illustrated by the cross section of Figure 2. This cross section, of greater regional extent and further west along the flank of the Wichita Mountains than the previous section, demonstrates clearly the existence of onlap of the Pennsylvanian system upon the flank of the mountains. It verifies the supposition that stratigraphic traps due to onlap may be expected both in the Marietta Syncline and the Palo Duro Basin within the Pennsylvanian System.

The truncation of the Mississippian beds by the unconformity at the base of the Pennsylvanian is shown to be an important factor in the consideration of stratigraphic trap possibilities. Especially since recent wells in the region have shown the Mississippian system to have thick, porous, and permeable, beds of lime and sand containing shows of oil. Under favorable trap conditions created by truncation these potential reservoir beds should become productive.

Although there is little information on the pre-Mississippian post-Cambrian formations in this region southwest of the Wichita Mountains, the gradually increasing evidence furnished by drilling indicates that the relationship of these beds to those above and below presents some interesting problems. In this connection it might be well to point out that on the cross section (Figure 2), which is drawn approximately at right angles to the strike of the beds, Tide Water Associated Oil Company's Johnson 1 in 19-3m-23w is much farther from the present axis of the Hollis Basin than is the California Oil Company's Wade 1 in 23-1n-25w. And yet Johnson 1 logged sections of Hunton, Viola, and Simpson below the Mississippian, whereas the Wade 1 went directly from Mississippian into Arbuckle. The problems implied by this relationship are well deserving of further study.

The map (Figure 3) is presented to illustrate, in a generalized form, the arrangement of the major structural features of the region and the possible pattern of distribution of favorable zones of stratigraphic traps prospects around these major structural features. This pattern of distribution of zones is deduced from an examination of the geologic conditions shown by the cross sections (Figures 1 and 2) when these conditions are considered in relation to the structural features of the region.

Drilling activity throughout the region has proven the existence of porous and permeable beds in the geologic section so far penetrated. Beds of the same respective ages are known to produce oil at one place or another in Oklahoma and Texas. In many cases this production is from stratigraphic traps. Furthermore, some of these same formations are known to produce from structural traps in this particular region southwest of the Wichita Mountains. It is logical to expect that these beds will produce from stratigraphic traps in this region where such traps are present.

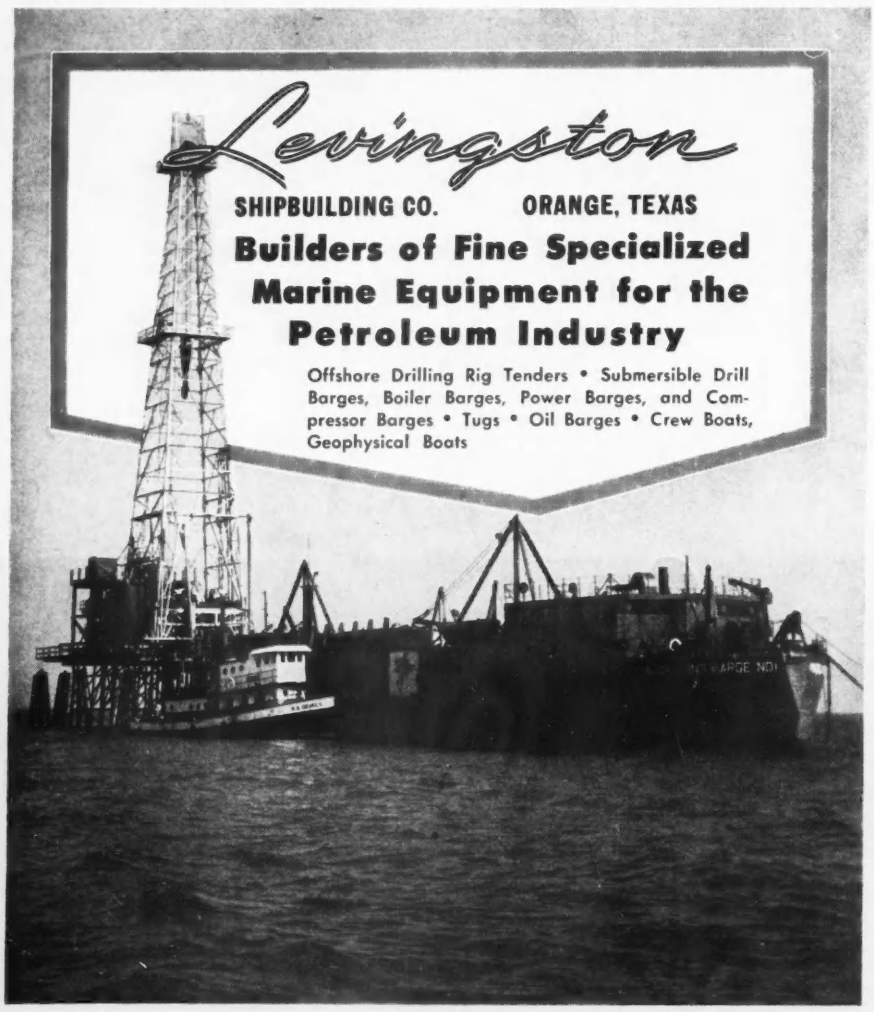
When all of these existing conditions are considered, it would seem that the conditions along the southwest flank of the Wichita Mountains, and around the flanks of both the major sedimentary basins in the region, fulfill the necessary requirements favorable to the existence of stratigraphic type oil reservoirs.

Future exploration, with these possibilities in mind, should result in the discovery of such oil fields in this region. At present, what might be called "strandline geology," based on use of numerous electric log cross sections, is the most effective means of exploration for stratigraphic traps in this province; although this is hindered considerably by the scarcity of logs available.

However, the possibility that many of these traps will be found at relatively shallow depths (above 4000 feet) may make the use of electrical resistivity methods of exploration an effective means of tracing the limits of possible producing sand sections.

Seismic work in this area has not appeared to be particularly effective in the isolation of stratigraphic traps. But this seems to be due more to the lack of properly coordinated application, coupled with problems inherent in the extremely rapid lateral changes in lithology that exist in the horizons above the Arbuckle-Ellengerger, rather than to any limitations of the method itself.

Geophysical exploration, when closely coordinated with regional and detailed geologic study, should enable the localization of favorable stratigraphic prospects in those portions of the region where drilling data are limited.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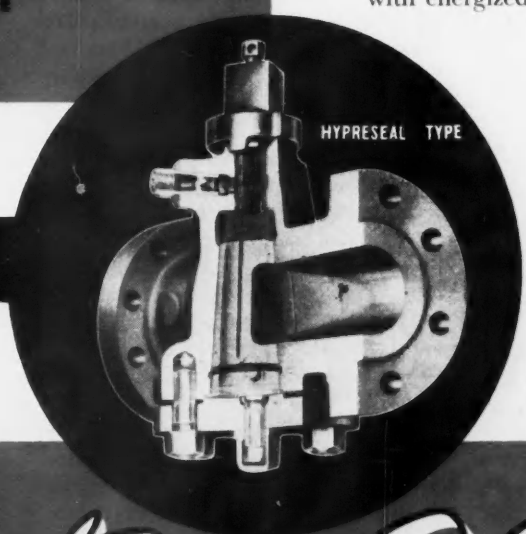

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Are Oil Shales Natural Source Beds of Petroleum?

By BERNARD J. FERRIS

Exploration Department, Shell Oil Company, Midland, Texas

MAXIMUM SUCCESS in oil exploration requires fullest possible knowledge of the fundamental nature of petroleum, including better understanding of the genesis and source materials of petroleum hydrocarbons. Coal, cannel coal, marine black shale, oil shale, limestone, and even coarse-grained clastic sediments have all been suggested as possible petroleum source beds. In this paper the author describes experiments which investigated the possibility that oil shales are natural source beds of petroleum and hydrocarbon gases. Prepared for WORLD OIL as condensation of a portion of a master's thesis in geological engineering, Shell Oil Company Fellowship in petroleum engineering, at the Colorado School of Mines, in Golden, Colo.

IN the early history of petroleum geology, it was generally believed that detailed studies of the generation, migration, and accumulation of petroleum were not only baffling, but highly impractical as well. However, the growing demand for oil throughout the world has stimulated such research, and it is now an established fact that the precision and success of oil exploration is a function of our knowledge of the fundamental nature of petroleum.

The problems concerning the genesis and source material of petroleum hydrocarbons are well known to most workers in the petroleum industry. Investigations of probable source beds of petroleum are exceedingly complex, inasmuch as the transformation of organic matter into petroleum commonly alters or destroys original structural characteristics, and thereby renders the primary substances unidentifiable. The study is further complicated by the large number of variable factors that exist in nature, and which cannot be accurately duplicated in the laboratory.

Coal, cannel coal, marine black shale, oil shale, limestone, and even coarse-grained clastic sediments have all been suggested as possible petroleum source beds. It is the purpose of this paper to describe experiments which investigated the possibility that oil shales are natural source beds of petroleum and hydrocarbon gases.

An oil shale is a fine-grained sedimentary rock containing pyrobituminous vegetable or animal debris, or both. It is characterized by the relatively low solubility of its organic constituents in petroleum solvents and by its capacity to generate oil and gas upon destructive distillation. The temperature of conversion ranges from about 350° C. to 400° C. (at atmospheric pressure) for most oil shales.

Microscopic examination of oil shales has shown that the organic constituents are of two general types:

1. A massive, structureless, amorphous, yellow-brown, isotropic substance. Bradley[1] has stated that this material appears perfectly homogeneous, even at magnifications of 1500.
2. Organisms or fragments of organisms imbedded within the homogeneous matter.

It is believed that the structureless, homogeneous component of oil shale is also composed of the remains of organisms, but that they have been so highly macerated and altered as to be unidentifiable. This matter is commonly referred to as "kerogen"; the use of this term is highly controversial, however, and may denote a variety of substances when used by different writers.

Although oil shales have been studied for many years, much additional information is needed concerning the physical and chemical properties of the organic matter which they contain.

Miscroscopic Studies of the Soluble Material in Oil Shales

It is an established fact that most oil shales (except certain of the Estonian shales) contain a comparatively small percentage of material which is instantaneously soluble in organic solvents at atmospheric temperatures and pressures. The exact nature of this soluble substance is not definitely known.

In an effort to determine some of the characteristics of this soluble material, thin sections of fresh samples of oil shale from the Green River formation of Garfield County, Colorado, were made in the usual manner, except that cover glasses were omitted. The thin sections were then observed through a microscope while droplets of carbon tetrachloride were placed on them with an eyedropper. No solution was visible, however. Photomicrographs were taken of selected areas on these slides, and the slides were then immersed in carbon tetrachloride at room temperature for varying periods of time. After specific time intervals, additional photomicrographs were taken. The figures in Plate 1 illustrate the results of this work.

Figure 1, Plate 1, is a photomicrograph of a Green River oil shale before immersion in carbon tetrachloride. The dark, horizontal streak in the center of the photograph is a brilliant amber color in plane polarized light. The streak appears to be an aggregate of some organic substance which has become concentrated by post-depositional processes.

Figures 2 and 3, Plate 1, are photomicrographs of the same area, taken after 24 and 48 hours immersion in carbon tetrachloride respectively.

It is of interest to note that solution apparently occurred uniformly throughout the "groundmass" of the shale, as is indicated by the successively lighter color of the disseminated organic matter with each additional exposure to the solvent. The color variation among the three photomicrographs is not entirely attributable to solution, however, since photographic variables such as intensity

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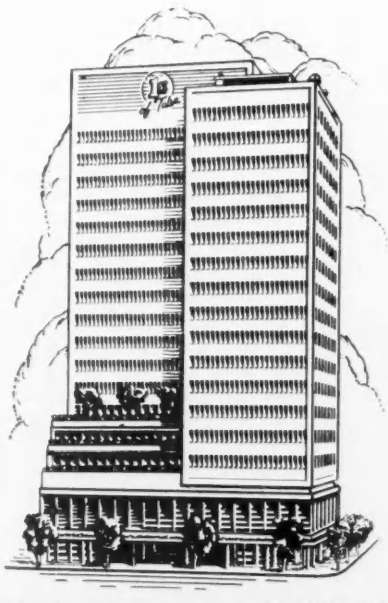

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STATEMENT OF CONDITION

JUNE 30, 1950

RESOURCES

Cash and Due from Banks	$53,805,056.26	
U. S. Government Securities	72,698,210.90	$126,503,267.16
Other Bonds and Securities		7,411,657.31
Loans and Discounts		58,272,567.47
Federal Reserve Bank Stock		240,000.00
Income Earned, Not Collected		451,324.22
Future Banking Quarters		1.00
Equipment—New Banking Quarters		340,791.63
Furniture and Fixtures		1.00
Customers' Liability Under Letters of Credit		631,062.50
Other Resources		29,148.77
		$193,879,821.06

LIABILITIES

Deposits		$181,747,411.20
Income Collected, Not Earned		298,146.63
Taxes, Interest and Expense—Accrued		537,969.06
Letters of Credit Outstanding		631,062.50
Capital	$3,000,000.00	
Surplus	5,000,000.00	
Undivided Profits	2,665,231.67	10,665,231.67
		$193,879,821.06

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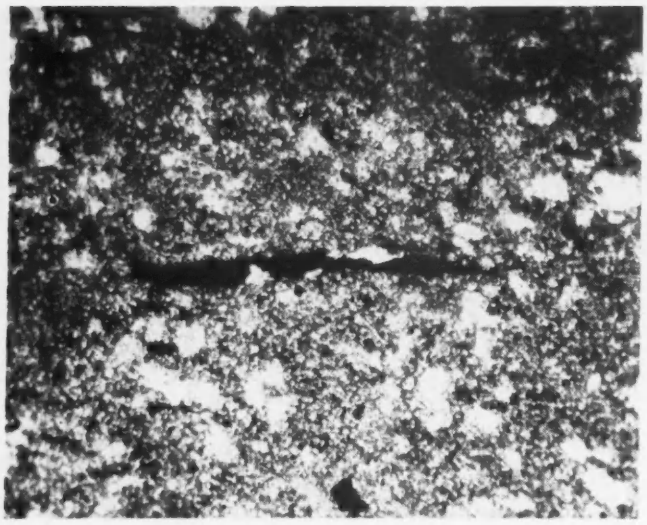

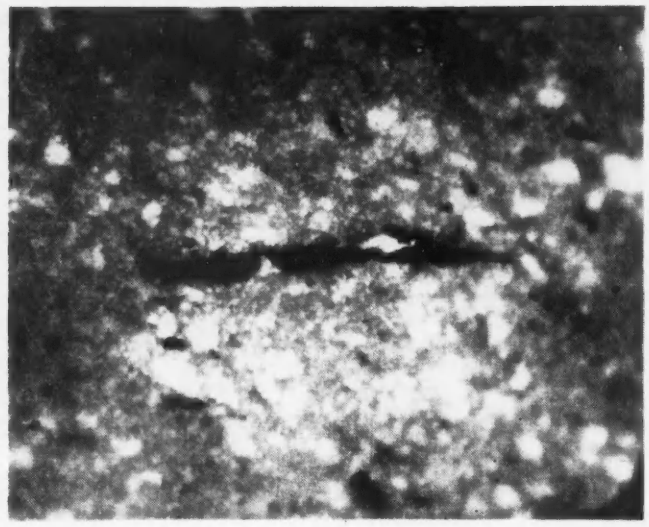

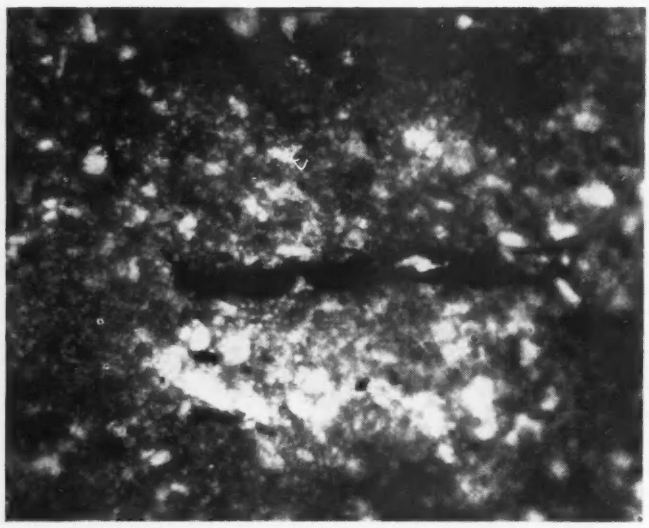

PLATE 1

FIGURE 1 (Top left). Photomicrograph of Green River oil shale before immersion in carbon tetrachloride. (X75)

FIGURE 2 (Top right). Photomicrograph of same thin section after immersion in carbon tetrachloride for 24 hours at room temperature. (X75)

FIGURE 3 (Left). Photomicrograph of the same thin section after immersion in carbon tetrachloride for 48 hours at room temperature. (X75)

of light, developing time, etc. undoubtedly affected the density of the prints.

It is particularly significant that the dark, organic aggregate has been attacked only slightly, if at all.

It was the writer's original intention to extend the solvent action on the thin sections over a period of several days. However, upon continued suspension in the carbon tetrachloride, the cement became cloudy and the shale slabs buckled, which made subsequent photomicrography impossible. Consequently, the thin sections were subjected to solvent action for no greater a period than 72 hours.

It may be concluded from these investigations that in the oil shales observed, the soluble organic constituents are uniformly dispersed throughout the shale, and do not necessarily exist as concentrated aggregates in a groundmass of less soluble, relatively uniform composition.

Solubility of "Kerogen" as a Function of Particle Size

In order to obtain additional data on the nature of the soluble organic substance in oil shales, a series of solvent extractions was run on a fresh sample of shale from the Green River formation of Garfield County, Colorado, in which the effect of particle size on solubility was studied. The extractions were made in a reflux extraction apparatus, using carbon tetrachloride as the solvent. It is a well-known fact that oil shales of the Green River formation frequently consist of alternately rich and lean laminations, and that they consequently vary considerably in assay value and in solubility throughout relatively short distances. Because of that fact, it is difficult to obtain a sample of the shale which is uniform in organic content. Consequently, to avoid the possibility of obtaining erroneous results through the testing of several samples, a single sample was utilized in these solubility determinations. After the shale was ground to the desired particle diameter, it was extracted for a length of time sufficient to exhaust completely the sample of its soluble constituents for that specific particle size. The sample was then dried and reground to a smaller size and reextracted. The percentage of soluble material thus obtained was added to the percentage of soluble extract previously obtained when the particles were not so finely comminuted. Thus, the solubility curve is actually a cumulative curve.

Increase in Solubility

It may be seen from Figure 1 that there is a notable increase in the solubility of the shale as particle size decreases. It is to be emphasized, however, that the solubility of other shales with different chemical and physical properties might be related quite differently to particle size.

It is seen from the curve that the greatest incremental increases in solubility exist between the 30-mesh and 120-mesh screen sizes. The very slight increase in soluble extract between the 120- and 170-mesh screen sizes indicates an approach toward complete extraction

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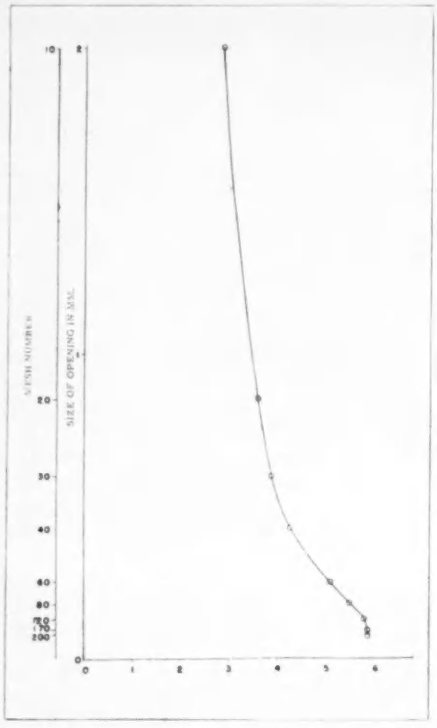

FIGURE 1. Curve showing relation between solubility of oil shale and particle size. Shale from Green River formation. Temperature of solvent (CCl_4)—75° C. Time of exposure to solvent—time required for complete extraction.

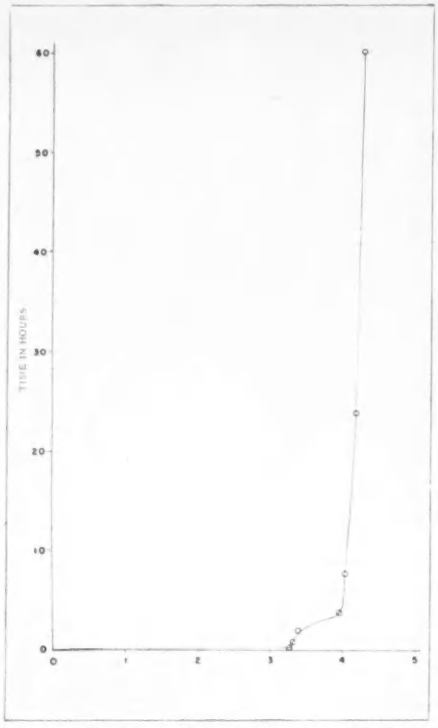

FIGURE 2. Curve showing relation between solubility of oil shale and time. Shale from Green River formation near Dragon, Utah; assay oil yield — 34 gallons per ton. Particle size — 60 mesh. Temperature of solvent (CCl_4)—75° C.

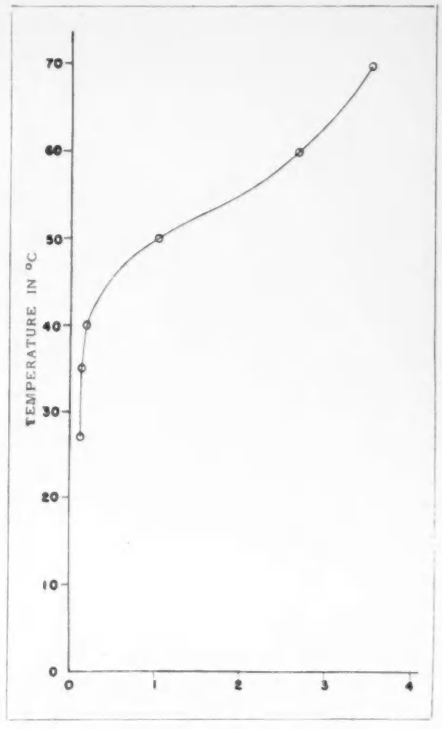

FIGURE 3. Curve showing relation between solubility of oil shale and temperature of solvent. Shale from Green River formation; assay oil yield — 40 gallons per ton. Particle size — 60 mesh. Time exposed to solvent (CCl_4)—six hours.

of soluble material from the shale. An extraction after the shale was ground to a 200-mesh size revealed no increase in extractable product over the extract obtained from the same shale ground to the 170-mesh size. Subsequent extractions of the shale ground to still finer sizes failed to indicate the existence of any remaining soluble matter.

Hawley[2] has stated that solubility may be somewhat increased by the oxidation of residual organic matter after the originally soluble material in oil shale has been extracted. Although this phenomenon may, in part, account for the solubility increases shown in Figure 1, its effect is believed to be minor in comparison with the effect of reduced particle size.

Three possible explanations for the inverse relation between solubility and particle size are:

1. The pressure exerted in grinding may cause a transformation of the shale into a more soluble substance.
2. Temperatures produced by interparticle friction during grinding may actually reach the conversion point of the oil shale which would cause its decomposition and transformation into soluble bitumen or oil.
3. The increased number of particles caused by the decrease in particle size exposes a greater surface to attack by the solvent.

In support of the first proposed explanation are the results of early investigations which suggested that liquid hydrocarbons or some ether-soluble bitumen were produced by the application of shearing pressures to oil shales at room temperatures. However, later research[3,4,5,6,7] conducted under more accurately controlled laboratory conditions has shown that:

1. In many cases, shear pressures do not produce an appreciable increase in solubility of the organic matter in oil shales.
2. In experiments where an increase in

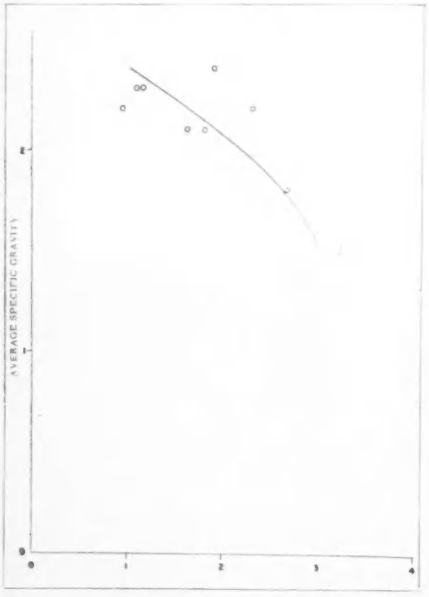

FIGURE 4. Curve showing relation between solubility of oil shale and specific gravity. Shale from Green River formation, Garfield County, Colorado; temperature of solvent (CCl_4)—75° C. Time of exposure to solvent—four hours.

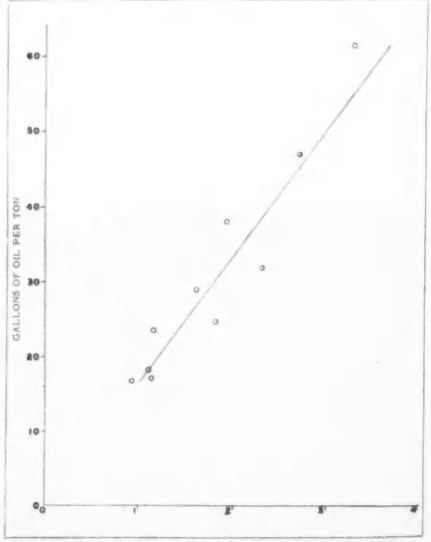

FIGURE 5. Curve showing relation between solubility of oil shale and modified Fisher oil assay. Shale from Green River formation, Garfield County, Colorado; temperature of solvent (CCl_4) —75° C. Time of exposure to solvent—four hours.

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Mud (Baroid, Quebracho, Aquagel): R_m = 1.2 @ B.H.T.
Bit Size: 9⅞"
Spacings: AM = 16"
AM' = 64"
AO = 18' 8"

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LOG ANALYSIS

1) Water saturation S

R_o = 0.8 ohms from neighboring well where sand is below water level. This value is used in calculations for both levels.

R_t = 19.0 ohms — Level A
R_t = 11.0 ohms — Level B
Bed thickness requires resistivity corrections for both levels.

In "A" Sand: $S = \sqrt{\frac{0.8}{19}} = 22\%$

In "B" Sand: $S = \sqrt{\frac{0.8}{11.0}} = 27\%$

2) Formation water resistivity R_w

$SP = -70 \log_{10} \frac{R_m}{R_w} = -95$ mv.,

This value used for both levels. SP in Level B is increased by 5% because of bed thickness.
R_w = 0.052 ohms at B.H.T.

3) Porosity p

$F = \frac{R_o}{R_w} = \frac{0.8}{.052} = 15.3$

$P = \sqrt[m]{\frac{1}{F}} = 22\%$ for m = 1.8

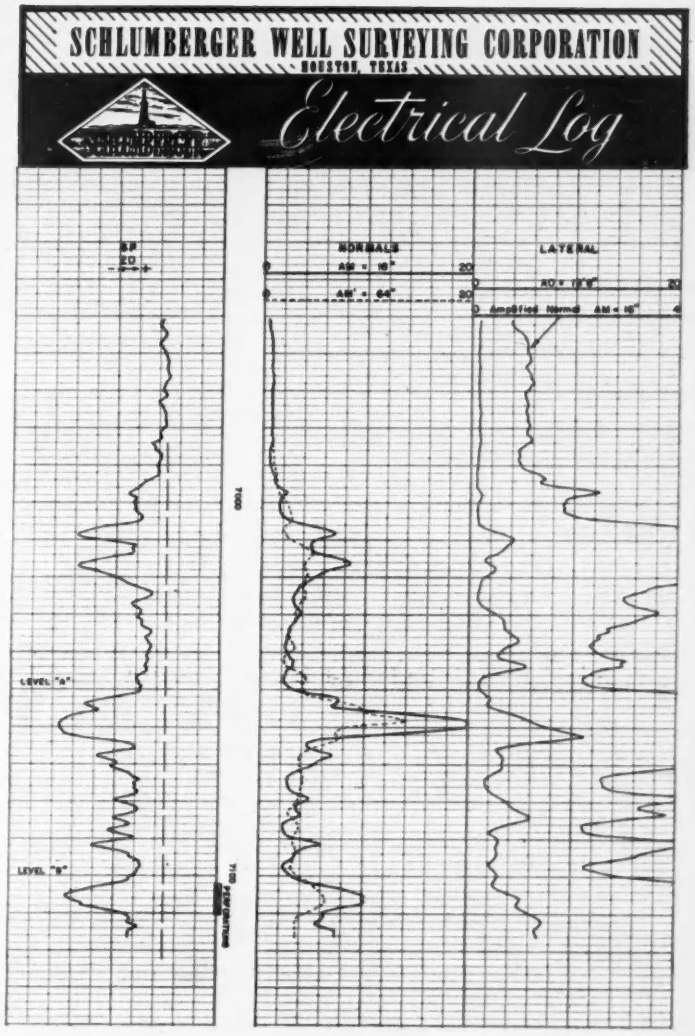
Same Values used for both levels.

CORE ANALYSIS

Level A	Porosity	22%
	Permeability	207 md
	Residual Water	46.0%
	Residual Oil	1.4%
	Connate Water	32%
Level B	Porosity	24%
	Permeability	359 md
	Residual Water	41.5%
	Residual Oil	14.9%
	Connate Water	31%

PRODUCTION RESULTS

Perforated: 7102-10'
Initial Production: 147 BOPD 37.2° API
Gas/Oil Ratio: 1970/1
Water: None



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solubility was obtained through the application of differential pressures, that increase was probably not a result of a chemical transformation within the shale, but was apparently due to the finer division of the shale caused by the shear.

In 1932, a paper appeared by Uwatoko[8] which described high radial axial pressure tests on oil shales and bituminous coal. These experiments were reported to be successful in the generation of liquid oil. The radial axial pressures, however, were applied in such a manner as to avoid failure of the specimens by fracture or flowage and attendant shear; consequently, the results of the experiments in an analysis of the problem of increased solubility with decreased particle size are of no significance, since fracture, shear, and possibly flowage are produced during grinding.

In 1935, Van Tuyl[9] reported on experimental work conducted at the Colorado School of Mines wherein pressures up to 200,000 pounds per square inch were applied to an Estonian shale for 68 days, and pressures of 250,000 pounds per square inch were applied to a Colorado oil shale for 20 days. No free oil was produced.

It may be concluded, therefore, that the greater solubility of oil shales ground to fine sizes is apparently not a result of any chemical conversion caused by pressure during grinding.

Fash[10] has emphasized the significance of the "skin-frictional heat" generated when one solid slides over another (the intensity of the heat being proportional to the force with which the solids are held in contact). It is his belief that this heat may be generated during sedimentary compaction by intergranular attrition, and that such heat might affect only the surface molecules of particles without appreciably raising their internal temperatures. Such heat, he theorizes, might, decompose "neokerogen" into various gases and liquids.

Although it is conceivable that such a temperature might be evolved during the grinding of an oil shale, the normal period of grinding is so short that any heat produced would either be so slight as to be negligible, or would readily escape into the atmosphere. When the oil shales were ground, the material was carefully observed for signs of temperature increase; no vapors or bituminous odors were noted, however. Furthermore, the shale at no time felt warmer than body heat when placed in the hand.

It is the writer's opinion, therefore, that frictional heat evolved during the grinding of the oil shale in these solubility experiments was not sufficient to cause a chemical transformation of the pyrobitumens in the shale.

Since it has been demonstrated that the solubility of oil shales is not increased by pressure or temperatures encountered in ordinary grinding, it is concluded that the greater solubility of small particles of oil shale is primarily a result of the greater amount of surface area exposed to the leaching action of the solvent.

Solubility of "Kerogen" as a Function of Time of Exposure to Solvent

In additional studies of the soluble matter in oil shales, several well-mixed samples from the same hand specimen of Green River oil shale were placed in carbon tetrachloride, and were extracted for various periods of time. The temperature of the solvent was held constant at 75° C; the shale was ground to pass a standard 60-mesh sieve.

Results of the test are illustrated in Figure 2. The curve in Figure 2 shows that the solubility of this oil shale is a direct function of time of exposure to the solvent. It is interesting to note, however, that the solubility does not progress at a uniform rate as the time of exposure is increased. Thus, in this test, 94.5 percent of the total dissolved matter was extracted in 6.6 percent of the total time of exposure, and 98 percent of the total dissolved matter was extracted in 13.3 percent of the total time.

Solubility of "Kerogen" as a Function of Temperature of Solvent

In this experiment, six samples of Green River shale from the same hand specimen were crushed to a 60-mesh size and were thoroughly mixed. Each sample was then extracted for six hours in carbon tetrachloride at various temperatures. Figure 3 indicates the results of this test.

As might be expected, the data obtained indicate that the solubility of the oil shale is a direct function of the temperature of the solvent. It is of interest to observe that the solubility of this shale was quite low and showed no marked increase until the 40° C. temperature was reached. From that point on, large solubility increases per unit of temperature occurred.

It is believed that a similar study using high pressures or high boiling point solvents, or both, might yield additional valuable information.

Solubility of "Kerogen" as a Function of Specific Gravity

In an effort to determine the relation between the percent of soluble extract in oil shales and their specific gravities, various samples of Green River oil shale of known specific gravity were ground to 60-mesh size, and were completely extracted in carbon tetrachloride at 75° C. The data obtained are illustrated in Figure 4.

Although the points plotted do not fall along a smooth curve, their general distribution indicates that there is an inverse relation between the percent of soluble extract in the Green River oil shales tested and their specific gravities.

Inasmuch as the organic matter in oil shale is less dense than the mineral constituents, it follows that the oil shales of lowest specific gravity should contain the greatest amount of organic material. As shown by the curve, this greater content of organic matter apparently manifests itself by a greater percent of soluble extract.

Solubility of "Kerogen" as a Function of Oil Yield

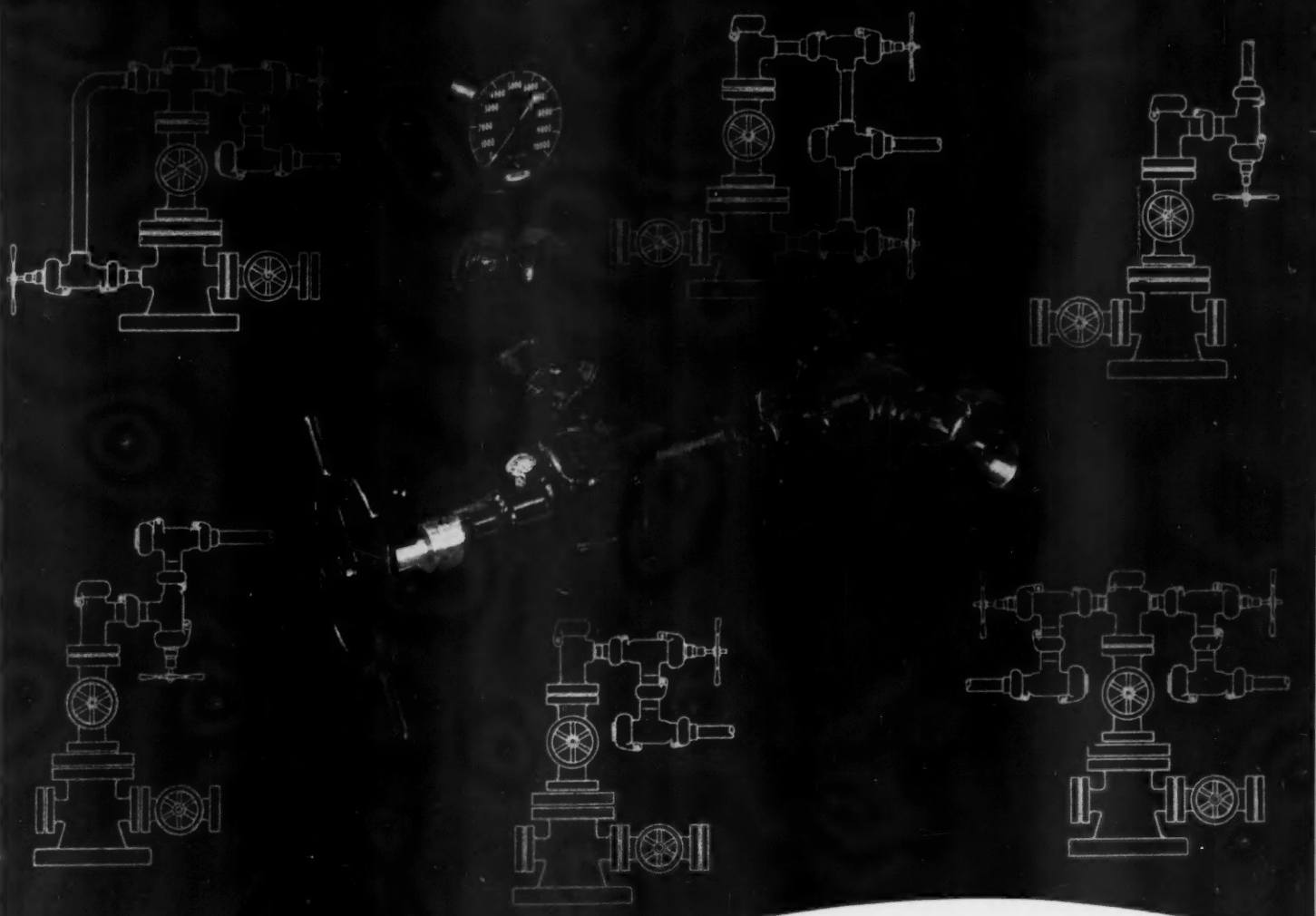
Since the soluble extract and oil yield of oil shale are direct functions of the organic content, it would seem that solubility and oil yield might also bear some close relationship to each other.

In a study of this relationship, the oil yields of ten samples of Green River oil shale were determined by modified Fisher assays. Samples identical with these were extracted in carbon tetrachloride at 75° C. The results of these tests are shown in Figure 5.

The values plotted are somewhat scat-

About the Author

BERNARD J. FERRIS was born in Denver. He graduated with a degree in Geological Engineering from the Colorado School of Mines in 1947, and received a master's degree in Geological Engineering from the same institution in 1948. His education was interrupted during World War II, during which time he served in the Corps of Engineers, U. S. Army. At "Mines" he was a student teaching assistant in the Geology Department, and was awarded the Shell Oil Company fellowship for graduate work in petroleum geology. He is now employed in the exploration department of Shell in Midland.



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tered; however, they show that soluble extract and oil yield are directly related in the shale tested.

It is possible that this relationship could be utilized in making rapid approximations of the oil yield of oil shale samples. By plotting a large number of values, a fairly accurate curve could be constructed expressing oil yield in terms of soluble extract. Then, by obtaining the percent of soluble extract of a shale of unknown assay value, its approximate oil yield could be determined from the curve.

It is obvious that such a procedure could be satisfactorily employed only in limited areas where oil shale samples remain relatively constant in composition and in lithology. It is also evident that many variables such as the type of solvent, time of exposure to solvent, temperature of solvent, particle size of sample, and pressure in the extraction system would have to be held constant throughout the various solubility determinations.

Conclusions

Because of the wide variation in the properties of various oil shales, conclusions stated herein should not be applied to oil shales in general, but only to those whose chemical, physical and lithologic characteristics are similar to those of the oil shales tested.

Conclusions reached as a result of the investigations described in this paper may be summarized as follows:

1. The soluble matter in Green River oil shale is apparently uniformly dispersed throughout the shale.
2. The greater solubility of the organic matter in oil shale particles of small size is primarily a result of the greater amount of surface area exposed to the leaching action of the solvent.
3. The relationship which exists between the soluble extract and the oil yield of Green River oil shale may provide a method for approximating the oil yield of oil shales of unknown assay value.
4. The solubility of the "kerogen" in Green River oil shale is:
   a. an inverse function of particle size;
   b. a direct function of time of exposure to the solvent;
   c. a direct function of the temperature of the solvent;
   d. an inverse function of specific gravity;
   e. a direct function of oil yield.

Other studies have shown that the soluble extract obtained from oil shale is also a function of the composition of the solvent, and of the pressure in the extraction system.

A second article on source beds of petroleum, prepared by the author for WORLD OIL, will be published in a later issue. Although independent of this article the second article will give answers to some points touched upon in this one.

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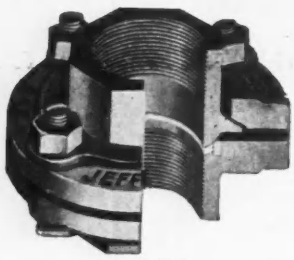

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Exploration

Continues High in June

A NEAR-RECORD number of exploratory wells was completed in June to boost the year's 6-months total to an 8.9 percent lead over last year's record-breaking activity. A total of 741 exploratory tests were finaled during the month and that was second only to the all-time monthly high of 770 completed during May.

A better-than-average number of June's wells proved to be producers, and as far as quantity was concerned, the month's efforts were considerably more successful than they had been a month earlier. Almost 25 percent of the tests drilled during June were completed as commercial producers, while in May a closer-to-average 19.6 percent was the score.

Principally due to the past 2 months' high exploratory drilling rates, wells completed in the first 6 months of 1950 totaled 3924, to set a new high for the period and to top the previous record of 3604 drilled during last year's first half by 8.9 percent. However, last year's exploration results had the edge percentage-wise, as productive tests amounted to 21.4 percent of the total and this year's averaged 20.4 percent.

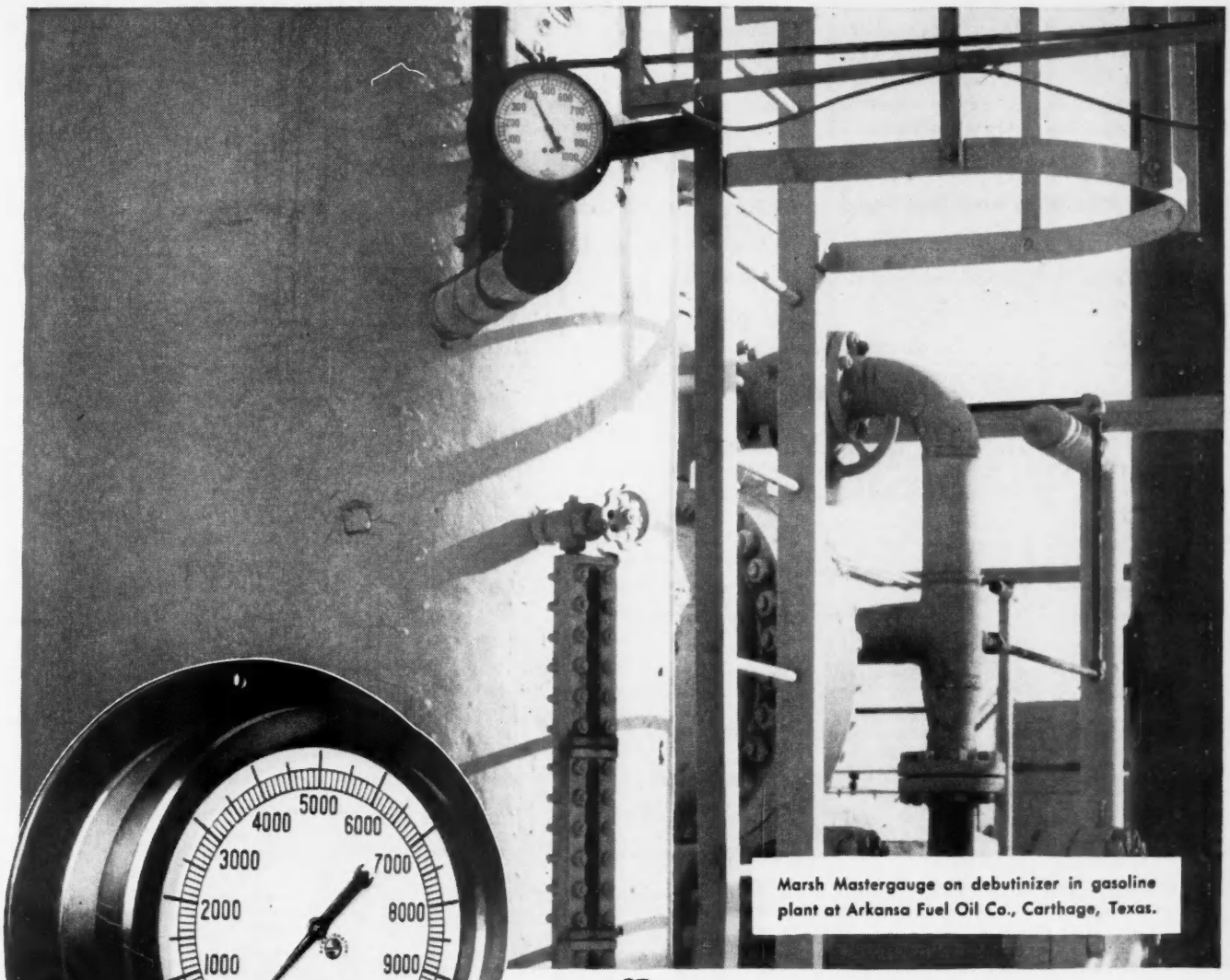
Summary of Results of Exploratory Drilling

ITEM	June, 1950	May, 1950	SIX MONTHS January-June 1950	1949	Percent Diff.
Oil Discoveries	118	101	524	494	+ 6.1
New Fields	84	72	379	331	+ 14.5
New Pays	34	29	145	163	— 11.0
Distillate Discoveries	10	4	41	77	— 46.8
New Fields	8	4	35	38	— 7.9
New Pays	2		6	39	— 84.6
Gas Discoveries	16	14	72	69	+ 4.3
New Fields	15	13	65	56	+ 16.1
New Pays	1	1	7	13	— 46.2
Total Discoveries	144	119	637	640	— 0.5
Extensions to Fields	38	32	165	133	+ 24.1
Oil Fields	37	28	149	118	+ 26.3
Distillate Fields		1	4	10	— 60.0
Gas Fields	1	3	12	5	+140.0
Total Prod. Tests	182	151	802	773	+ 3.8
Dry Holes	559	619	3,122	2,831	+ 10.3
Wildcats	545	602	3,004	2,797	+ 7.4
New Pays	1		6	2	+200.0
Outposts	13	17	112	32	+250.0
Total Expl'tory Tests	741	770	3,924	3,604	+ 8.9
Percent Productive	24.6	19.6	20.4	21.4	
Percent Dry	75.4	80.4	79.6	78.6	

(Text continued on page 92. See tables on pages 92-94-96)

Results of Exploratory Drilling in June and First Six Months, 1950-1949, by Districts

State or District	MONTH OF JUNE, 1950													FIRST SIX MONTHS, 1950																	
	Productive Tests									Total Productive	Unproductive Tests			Total Exploratory Tests	Productive Tests								Unproductive Tests				Total Exploratory Tests	
	New Fields			New Pays			Extensions								New Fields			New Pays			Extensions			Total Productive				Total Dry			
	Oil	Dis.	Gas	Oil	Dis.	Gas	Oil	Dis.	Gas		Wildcats	New Pays	Outposts		Oil	Dis.	Gas	Oil	Dis.	Gas	Oil	Dis.	Gas	6 Mo. 1950	6 Mo. 1949	Wildcats	New Pays	Outposts	6 Mo. 1950	6 Mo. 1949	6 Mo. 1950	6 Mo. 1949
Alabama	1									1				1	1		1							2		8			8	6	10	6
Arizona																														3		3
Arkansas				1			1			2	8			10	4	1		1			1			7	6	40		2	42	29	49	35
California	1			2		1	3			7	21	1	1	30	10		1	5		1	9		1	27	26	162	3	9	174	161	201	187
Colorado	1									1	4			5	1									1		17		1	18	21	19	21
Florida											1			1												6			6	8	6	8
Georgia											1			1												4			4	4	4	4
Idaho																										3			3		3	
Illinois	4			5			10			19	65			84	12			9			37		1	59	46	314			314	241	373	287
Indiana	6									6	44			50	17			3			1			21	29	202		7	209	188	230	217
Kansas	8		2							10	51			61	49		3							52	45	280			280	187	332	232
Kentucky	3			1			1			5	10			15	5		1	1			1			8	6	26			26	20	34	26
Louisiana	1	1		4	2		1			9	14			23	13	8	2	10	4	2	8		1	48	60	94	1		95	114	143	174
North Louisiana	1			1			1			3	8			11	2	1		1	2	2	5		1	14	15	41	1		42	58	56	73
South Louisiana		1		3	2					6	6			12	11	7	2	9	2		3			34	45	53			53	56	87	101
Maryland																										1			1		1	
Michigan	3									3	17			20	16		4	1			1			22	18	122			122	159	144	177
Mississippi	1									1	12			13	8	2		1				2		13	5	74		3	77	58	90	63
Missouri																										2			2	1	2	1
Montana											5			5							1			1	1	26			26	12	27	13
Nebraska											6			6	1		1				1		1	4	1	20			20	1	24	2
New Mexico	1						1			2	12		1	15	9			4			6			19	8	32		4	36	30	55	38
Ohio											1			1							1		1	2	3	6			6	19	8	22
Oklahoma	10		2	3			10			25	39			64	42		4	17			21	1	1	86	60	250			250	218	336	278
Pennsylvania																									1				1		2
South Dakota																										2			2	1	2	1
Tennessee																									1	4			4	10	4	11
Texas	44	7	11	17			10		1	90	226		11	327	187	24	48	88	2	4	59	1	6	419	431	1267	1	83	1351	1272	1770	1703
Dist. 1 S. Central	1	1								2	16		1	19	7	1	1			1				10	11	95		2	97	121	107	132
Dist. 2 Middle Gulf	1		2	2					1	6	12		1	19	7	4	10	5	1	1			2	30	40	60		7	67	81	97	121
Dist. 3 Upper Gulf		1	2	3			1			7	23		1	31	6	5	3	19	1	1	6	1	3	45	72	95		11	106	127	151	199
Dist. 4 L. Gulf-SW	3	2	5	5						15	37			52	12	5	15	24			1			57	62	155		3	158	192	215	254
Dist. 5 E. Central											7			7	2						1			3	3	33			33	37	36	40
Dist. 6 Northeast	1									1	4		1	6	5	3		2			2		1	13	13	39	1	4	44	33	57	46
Dist. 7-B N. Central	23	2		1			1			27	44		2	73	69	3	8	9			5			94	92	274		15	289	289	383	381
Dist. 7-C W. Central	2	1	1	1						5	14		1	20	8	2	2	5			5			22	16	85		10	95	47	117	63
Dist. 8 West	4			4			7			15	17		2	34	31			18			26			75	47	130		14	144	102	219	149
Dist. 9 North	9		1	1			1			12	50		2	64	39	1	9	6			14			69	74	295		17	312	240	381	314
Dist. 10 Panhandle											2			2	1									1	1	6			6	3	7	4
Utah											1			1				1						1	2	5			5	6	6	8
Washington															1									1	1	1			1		2	
West Virginia																									4				1		5
Wyoming				1						1	7			8	3			4			2			9	20	36	1	3	40	60	49	80
Total U.S.	84	8	15	34	2	1	37		1	182	545	1	13	741	379	35	65	145	6	7	149	4	12	802	773	3004	6	112	3122	2831	3924	3604



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New crude oil pools discovered so far this year numbered 524 for a gain of 6.1 percent over the 494 found a year ago. Those new pools were made up of 379 new fields and 145 new pay horizons in previously established fields. In the same period of 1949, new fields numbered 331 and new oil pays totaled 163.

A slight step-up in natural gas discoveries was also recorded. Those totaled 72 against 69 a year before. New distillate pools uncovered this year totaled only 41 and failed to match last year's 77.

The remaining 165 producing exploratory tests successfully extended the boundaries of existing fields by at least ½-mile. Those included 149 oil wells, 4 distillate producers and 12 gassers.

New Oil, Distillate and Gas Fields and New Pay Horizons Discovered in the United States in June, 1950

Also Important Extensions to Established Fields

COUNTY	FIELD	COMPANY, WELL AND LOCATION	Date Completed	Total Depth (Feet)	Completion Horizon (Feet)	[1]Name, Character and Age of Producing Formation	[2]Initial Production Method and Choke	Gravity of Oil
		ALABAMA—New Oil Field						
Clarke	"Carlton"	Humble O&R Co's Marion Wall Davies et al 1, c sw nw 15-3n-2e. 2 mi se of Carlton.	5-29-50	8093	5419- 5428	Tuscaloosa sd; U. Cre.	P 86	18.2
		ARKANSAS—New Oil Pay						
Union	Catesville	C. H. Murphy & Co's Sue Olson 2, 589 fr nl 593 fr el nw ne 32-18s-15w.	6-19-50	7779	7718- 7720	Smackover li; Jur.	F 120; ⅛"	
		ARKANSAS—Oil Field Extension						
LaFayette	Spirit Lake	J. J. Broadus' J. W. Velvin 1, c ne ne nw 22-16s-25w. 2 mi w extension.	6-20-50	4195	4188- 4195	Kilpatrick li; L. Cre.	F 110	33
		CALIFORNIA—New Oil Field						
Kern		Shell Oil Company's Well 63X23, 1963 s 1841 w fr ne cor Sect. 23-27s-19e. Antelope Hills area.	6- 3-50	3252	2267- 2360		F 500	15.3
		CALIFORNIA—New Oil Pays						
Kern	Turis Creek	D. K. Associates' Corral 73-29, 1890 s 760 w fr ne cor Sect. 29-11n-18w.	6-18-50	1740	1565- 1675		P 305	33
Los Angeles	Del Valle	R. E. Havenstrite's Lincoln 16, 1293 n 2207 w fr se cor Sect. 16-4n-17w.	5-25-50	13038	10100-10235		F 100	29
		CALIFORNIA—Oil Field Extensions						
Fresno	Guijarral Hills	Standard Oil Company's 27-F, 972 n 1650 w fr se cor Sect. 27-20s-16e. Nw extension.	6-25-50	8214	8152- 8206	Allison sd; Mio.	P 150	35.3
Los Angeles	Signal Hill	R. W. Jerman & Frank R. Bartee's Webb 1, 260 n 130 w fr c/l 15th St. Sect. 33-4s-12w. 1 mi e extension.	6-24-50	7551	6440- 7551		P 660	28.6
San Luis Obispo	Cuyama, N.	Bishop Oil Company's Chorum 67-10, 1002 n 999 e fr s¼ cor Sect. 10-11n-28w, s extension.	6-24-50	2175	1823- 1830	Morales sd; U. Mio.	P 50	29.2
		CALIFORNIA—New Gas Pay						
Sacramento	Rio Vista, E.	Brazos O&G Co's River Islands Land Company 1, 2100 s 660 e fr nw cor Sect. 29-4n-4e.	6- 6-50	5158	4160- 4170	L. Ione sd; Eoc.	F 4.5 mln; open	
		COLORADO—New Oil Field						
Logan		British American-Plains Exploration Co. et al's H. Segelke 1, ne nw ne 26-11n-53w Armstrong area.	6-13-50	5793	5406- 5416	3rd Graneros sd; U. Cre.	P 60; 30 wtr	40
		ILLINOIS—New Oil Fields						
Franklin	Whittington, S.	W. Duncan's U. S. Coal & Coke 1, ne nw ne 4-6s-3e. 2 mi s of Whittington fld.	6-30-50	2953	2578- 2614	Cypress sd; Miss.	P 41; 5 wtr.	
Hamilton	Cantrell, S.	George & Wrather & W. Duncan's R. P. Droit 1, se se sw 7-7s-5e. 1 mi s of Cantrell fld.	6-27-50	3393	3197- 3200	Rosiclare li; Miss.	F 430; 20 wtr.	
Marion	Kinmundy	H. Luttrell's T. E. Robb 1, 380 sl 330 el ne se 19-4n-3e. 2½ mi ne of Alma fld.	6-13-50	1917	1910- 1913	Bethel sd; Miss.	P 27; 35 wtr.	
Richland	Ritter	Calvert & Co's C. L. Jordan 1, nw ne ne 25-3n-10e, 3½ mi ne of Calhoun F. fld.	6- 6-50	3210	3198- 3209	Rosiclare li; Miss.	F 991; 18 wtr.	
		ILLINOIS—New Oil Pays						
Bond	Woburn, S.	Miami Operating Co's Besserman 2-A, 330 nl 390 wl ne se 16-6n-2w.	6-27-50	868	860- 868	Cypress sd; Miss.	P 40; 2 wtr.	
Edwards	Parkersburg, S.	Cullum & Lawhead's F. Koehler 1, 980 nl 400 wl nw se 8-1n-14w.	6-13-50	1394	1387- 1394	Pennsylvanian sd; Penn.	P 41; 23 wtr.	
Lawrence	St. Francisville, E.	J. E. Bauer's J. M. Brevcort 2, ne ne sw 10-2n-11w.	6-13-50	1467	1457- 1461	Hardinsburg sd; Miss.	P 40; 180 wtr.	
Saline	Eldorado	Ryan Oil Co's L. T. Stinson 1, se ne nw 17-8s-7e. 1 mi s of prod.	6- 6-50	1950	1940- 1947	Palestine sd; Miss.	P 12; 60 wtr.	
White	Enfield	Superior Oil Co's I. J. Dunn 1, nw nw ne 29-5s-8e.	6-20-50	3497	3420- 3426	McClosky li; Miss.	P 21; 6 wtr.	
		ILLINOIS—Oil Field Extensions						
Clinton	Beaver Creek	T. R. Kerwin's Bass 1, nw se nw 1-3n-3w, 1 mi sw extension.	6-20-50	1153	1147- 1152	Bethel li; Miss.	P 14; 5 wtr.	
Edwards	Maplegrove	A. J. Slagter, Jr's Knaust 1, sw se nw 20-1n-10e. 1 mi sw extension.	6-13-50	3239	3232- 3235	L. O'Hara li; Miss.	P 171; 2 wtr.	
Fayette	S. James	R. Halbert et al's Reece 1, se sw sw 18-6n-3e. ¾ mi n extension.	6- 6-50	1792	1600- 1621	Cypress sd; Miss.	P 12; 5 wtr.	
Wabash	Maud Cons.	Ashland et al's P. Deisher 1, se se se 29-1n-13w. ¾ mi nw extension.	6-20-50	2768	2510- 2531	Bethel sd; Miss.	P 9; 9 wtr.	
Wabash	NewHarmony-Keensburg Cons.	Illinois Mid-Continent's Shannon-Schrodt 1, 1650 sl 330 wl sw¼ 19-2s-13w. ½ mi extension.	6- 6-50	2929	2468- 2488	Cypress sd; Miss.	P 80; 16 wtr.	
Wayne	Clay City-Noble Cons.	Watkins Drilling Co's M. Redd 1, se ne se 26-1s-6e. ¾ mi w extension.	6-13-50	3254	3226- 3234	McClosky li; Miss.	P 80	
White	Crossville	Illinois Mid-Continent's Pitland 1, nw se ne 11-4s-10e. ¾ mi ne extension.	6-20-50	3225	2906- 2921	Bethel sd; Miss.	P 12	
White	Goldengate Cons.	Sohio Oil Co's L. J. Williams 1, se se sw 34-3s-9e. 1½ mi s extension.	6-20-50	3342	3324- 3334	Aux Vases sd; Miss.	P 117; 9 wtr.	
White	Herald	Nash Redwine's C. C. Aud 1, nw sw ne 33-6s-9e, ¾ mi extension.	6-13-50	3202	2379- 2394	Waltersburg sd; Miss.	P 45	
		ILLINOIS—Oil Field Extensions						
White	Maunie, S.	C. E. Skiles' E. B. Alford 1, ne nw ne 18-6e-11e. ¾ mi ne extension.	6-13-50	2607	2594- 2607	Cypress sd; Miss.	P 119	
		INDIANA—New Oil Fields						
Dubois		Stanley Krempp's Edwin Krempp 1, 450 fr sl 330 fr wl sw nw se 6-2s-4w.	6-19-50	682	674- 676	McCloskey li; Miss.	P 5; 80 wtr.	
Gibson		George & Wrather's Edward Weber 1, ne ne nw 36-2s-10w. 2 mi sw of Francisco.	6-20-50	2020	1878- 1884	Aux Vases li; Miss.	P 56	
Knox	Monroe City, W.	Aurora Gasoline Co. et al's Clark Wells 1, nw se nw Don 165-2n-9w. 6 mi fr production.	6- 2-50	1940	1536- 1549	Aux Vases li; U. Miss.	P 10; 10 wtr.	
Pike		Ryan & Sharp's Enos Coal Co. 3, sw se se 4-4s-8w. 4 mi e of Summerville.	6-18-50	1380	1360- 1380	Cypress sd; Miss.	P 300	
Vanderburgh		Joe Reznik's Herman Ross 1, nw se se 35-5s-11w. 5 mi n of Evansville.	6- 1-50	993	889- 993	Mansfield sd; Penn.	F 30	
Warrick	Heilman	H. C. Farmer & Waller Chenault's Lewis Robinson 1, ne nw nw 20-4s-6w. 8 mi fr production.	6-21-50	1293	1290- 1293	McClosky li; Miss.	P 15	
		KANSAS—New Oil Fields						
Graham	Bass	C-G Drilling Co & D. G. Hansen's Bass 1, nw nw sw 12-10s-21w. 1 mi sw of Muillenburg fld.	6-25-50	3833	3826- 3833	Arbuckle li; Ord.	P 128	31.2
Graham	Teall, N. E.	Hartman's Martin-Webster 1, ne ne ne 9-10s-21w. ½ mi n of Teall fld.	6-13-50	3845	3696- 3704	Lansing-K.C. li; Penn.	P 299	38
Greenwood		Butler & Jones' Hall 1, c el sw nw 33-25s-11e, betw. Eureka & Tonavay flds.	6-23-50	1977	1936- 1977	Mississippian li; Miss.	P 30	
Marion		Raymond Gear et al's Robinson 1, sw sw ne 31-20s-5e. 3 mi n of Florence fld.	6- 6-50	2566	2531- 2566	Viola li; Ord.	P 18	27
Morris		Koester & Mergen's Burns 1, sw nw sw 25-16s-6e. 4 mi n of Burdick fld.	6- 8-50	2252	2207- 2252	Mississippian li; Miss.	P 40	
Russell	Cook	H. H. Blair's Cook 1, nw nw se 26-13s-15w. ½ mi sw of Atherton, W. fld.	6-13-50	3074	3051- 3074	Lansing li; Penn.	P 46	
Saline		E. K. Carey et al's Swenson 1, ne nw sw 34-15s-3w. ¾ mi n of Olsson fld.	6-10-50	3371	3340- 3371	Viola li; Ord.	P 30; 5 wtr.	
Stafford	Pendsack, S.W.	Petroleum Inc's Russell 1, sw se nw 25-21s-14w. 1½ mi sw of Pundsack fld.	6-15-50	3772	3575- 3582	Lansing li; Penn.	P 256	
		KANSAS—New Gas Fields						
Harper		Deep Rock Oil Corp's Stoddard 1, sw sw sw 17-31s-8w. 1 mi s & 1 mi e of Grabs fld.	6-12-50	4975	4383- 4398	Mississippian li; Miss.	F 1.5 mln.	
Rice		Brusnon Drilling Co's Graham 1, c el se sw 28-20s-28w. 3 mi nw of Wherry fld.	6-14-50	3469	3275- 3315	Congolmenrate	F 1 mln.	
		KENTUCKY—New Oil Fields						
Daviess		Joe Reznik's Bessie Fuqua 1, nw se nw 13-O-34, 4 mi se Hawesville.	6-10-50	261	240- 261	Tar Springs sd; Miss.	P 20	
Henderson		Delta Drilling, W. F. Lacy and Pacific Operating Co's A.B. Elben 1, nw sw se 6-O-23. 2 mi n Cairo.	6- 2-50	1788	1778- 1785	Waltersburg sd; Miss.	P 13	

[1] Character of producing formations abbreviated thus: ch, chalk; dolo, dolomite; li, limestone; sd, sandstone; sh, shale; ser, serpentine; cgl, conglomerate. Ages of formation abbreviated thus: Plio, Pliocene; Mio, Miocene; Olig, Oligocene; Eoc, Eocene; U. Cre, Upper Cretaceous; L. Cre, Lower Cretaceous; Jur, Jurassic; Tri, Triassic; Perm, Permian; Penn, Pennsylvanian; U. Miss, Upper Mississippian; L. Miss, Lower Mississippian; Devo, Devonian; Sil, Silurian; Ord, Ordovician; Cam, Cambrian.

[2] Barrels of oil per day (24 hour rate), flowing (F), pumping (P), swabbing (Sw), or bailing (B); or million cubic feet of gas daily open flow capacity; size of choke given in inches.

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STATEMENT OF CONDITION

June 30, 1950

RESOURCES

Cash and Due from Banks	$52,664,693.51	
U. S. Government Securities	74,367,118.61	
Other Bonds and Warrants	5,302,985.91	$132,334,798.03
Loans and Discounts		36,109,347.89
Overdrafts		27,922.75
Income Receivable Accrued		382,353.50
Prepaid Expenses		62,152.22
Stock in Federal Reserve Bank		180,000.00
Bank Premises		2,000,000.00
Customers' Liability Under Acceptances		34,254.00
Total		$171,130,828.39

LIABILITIES

Deposits		$158,913,613.45
Acceptances Executed		34,254.00
Income Collected, Not Earned		160,767.67
Reserve for Taxes, Interest, etc.		763,510.74
Dividends Declared*		150,000.00
Capital—Common	$3,000,000.00	
Surplus	3,000,000.00	
Undivided Profits and Reserves	5,108,682.53	11,108,682.53
Total		$171,130,828.39

*Payable $75,000.00 July 14, 1950, $75,000.00 October 13, 1950

NATIONAL BANK OF TULSA

The Oil Bank of America

MEMBER FEDERAL DEPOSIT INSURANCE CORPORATION

OFFERING COMPLETE BANKING AND TRUST SERVICES

New Oil, Distillate and Gas Fields and New Pay Horizons Discovered in the United States in June, 1950

Also Important Extensions to Established Fields

COUNTY	FIELD	COMPANY, WELL AND LOCATION	Date Completed	Total Depth (Feet)	Completion Horizon (Feet)	[1]Name, Character and Age of Producing Formation	[2]Initial Production Method and Choke	Gravity of Oil
Henderson	Zion, N.	R. E. Hupp et al & C. E. Skile's Crafton-Baskett 1, ne ne 4-P-25. 2 mi sw of Spottsville fld.	6-27-50	2236	2225- 2236	McClosky li; Miss.	F 240	....
		KENTUCKY—New Oil Pay						
Henderson	Poole, W.	Fred Meyer, Jr's Edgar Allen 1, 6-N-23. 1 mi nw of Poole fld.	6-25-50	1873	1864- 1873	Tar Springs sd; U. Miss.	P 83	....
		KENTUCKY—Oil Field Extension						
Henderson	Tunnel Hill	Delta Drilling, W. F. Lacy & Pacific Operating Co's C. H. Overfield 1, se se sw 23-O-23. ½ mi ne extension.	6-12-50	1780	1768- 1780	Waltersburg sd; Miss.	P 100; 15 wtr.	....
		NORTH LOUISIANA—New Oil Field						
Tensas		David M. Lide Co's State-Harris Unit 1, 660 s 2211.42 w of ne cor 40-12n-12e. 1 mi se of Lake Bruin.	6-21-50	8910	8897- 8907	Tuscaloosa sd; U. Cre.	F 100; 1/8"	59.2
		NORTH LOUISIANA—New Oil Pay						
De Soto	Logansport	Skelly Oil Co's Eliza Pyle 1, c ne nw sw 5-12n-16w.	6-19-50	6458	6154- 6236	Pettit li; Cre.	F 48; 1/4"	41.7
		NORTH LOUISIANA—Oil Field Extension						
Claiborne	Haynesville, E.	Hunt Oil Co's T. S. Sale, Jr. et al 1, 1460 fr nl 1459 fr el 12-23n-7w. ¾ mi ne extension.	6-24-50	10502	10395-10423	Smackover li; Jur.	F 401; 3/16"	46.6
		SOUTH LOUISIANA—New Oil Pays						
Assumption	Napoleonville	J. M. Flaitz's Dr. H. A. LeBlanc 1 (OWDD) 1654 s 1091 w of ne cor Sect. 45-12s-13e.	6- 9-50	5547	5346- 5352		F 170; 1/8"	35.1
La Fourche	Valentine	Joe W. Brown's South Coast Corp. et al 2, Sect. 100-17s-20e. on ne flank	6-17-50	12548	11880-11884		F 224; 1/8"	38
Plaquemines	S. Pass Area, Blk. 24	Shell Oil Co's St. Lse 1008-2, 3300 fr el 1980 fr nl of Blk 24, in Gulf of Mexico	6- 2-50	9688	8054- 8060		F 82; 1/8"	29.5
		SOUTH LOUISIANA—New Distillate Field						
St. Landry		Magnolia Petroleum Co's Alice B. Rozas 1, Sect. 41-6s-4e. 2 mi ne of Opelousas.	6-26-50	14000	11412-11422		F 225; 2.3. mln; 3/16"	49.4
		SOUTH LOUISIANA—New Distillate Pays						
Acadia	Iota	Southern Six Drilling Co's Martin Pousson 1, c nw nw se 24-8s-2w. ¾ mi se of production.	6-16-50	9598	9377- 9379		F 83; 2.1 mln. 1/32"	57.3
LaFourche	Lake Raccourci	Humble O&R Co's Lake Raccourci State Lse, 1451-1.	6- 9-50	13000	8970- 9010		F 52; .7 mln. 1/8"	60.2
		MICHIGAN—New Oil Fields						
Allegan		George F. Lister's Laraway 1, sw ne sw 7-1n-15w. 1 mi sw of Pullman, E. fld.	6- 7-50	1205	1200- 1205	Traverse li; Devo.	P 12	....
Bay	Gibson	Ervin Major's Nichols 1, se se se 2-18n-3e. 1 mi s of Adams S. fld. Reopens Gibson fld.	6- 8-50	2145	2020- 2030	Traversel li; Devo.	P 12	....
Kent		McClanahan Oil Co. & W. S. Temples' Post 1, sw sw ne 35-9n-11w. Algoma twp.	6-27-50	2342	2334- 2342	Traverse li; Devo.	P 60	....
		MISSISSIPPI—New Oil Field						
Adams	"Kingston"	Plains Production Co's W. C. Walker et ux 1, Sect. 11-5n-2w, ½ mi sw of Kingston.	6- 1-50	6801	6654- 6656	L. Wilcox sd; Eoc.	F 54; 1/8"	42
		NEW MEXICO—New Oil Field						
Eddy		Franklin, Aston & Fair's Nelson 2, 2310 fr nl 330 fr wl of Sect. 4-18s-30e. 1½ mi e of Loco Hills fld.	6- 2-50	3519	3268- 3519	San Andres li; Perm.	P 50; 5 wtr.	36
		NEW MEXICO—Oil Field Extension						
Eddy	Watkins	Olen Featherstone's State 1, ne ne se 36-18s-31e. ½ mi w extension	6- 2-50	3130	3113- 3130	Seven Rivers sd; Perm.	P 27	36.8
		OKLAHOMA—New Oil Fields						
Lincoln	Mammoth	The Texas Co's M. M. Watson 2, se ne nw 9-12n-3e. 6 mi nw of Meeker.	6- 8-50	4709	4694- 4709	Red Fork sd; Penn.	F 84; 1/16"	35.4
Lincoln	Sparks, E.	J. R. McLean's North 1, sw se nw 9-13n-5e. 4 mi s of Davenport S. fld.	6-10-50	3525	3507- 3525	Prue sd; Penn.	F 165; 3/8"	41
Okfuskee		Lottis Drilling Co's Kenneda Unit 1 (OWWO) ne ne se 14-12n-9e. Morse district.	6- 2-50	3705	3048- 3057	Gilcrease sd; Penn.	F 35	....
Osage	Grayhorse, N.	Norbla Oil Co's Osage 1, ne nw nw 15-24n-6e.	6-23-50	2715	2705- 2715	Cherokee sd; Penn.	P 45	....
Osage		Chas. W. Oliphant's Osage 1, ne sw ne 30-25n-9e.	6- 8-50	2676	2592- 2676	Layton sd; Penn.	F 290; open	....
Pawnee		R. S. Shade's Colclazier 1, E½ ne sw 15-22n-5e. 3 mi n of Pawnee Res. fld.	6-24-50	3544	3534- 3544	Misener-Wilcox sd; Miss.	F 12; ¾"	40.6
Pontotoc		Smyth & Criswell's Norris 1, sw se sw se 34-4n-6e.	6-13-50	1320	1193- 1206		F 4	33
Pottawatomie	Garden Grove, S.W.	Gulf Oil Co's C. F. Jezek 1, sw se ne 2-11n-6e. 4 mi se of Prague	6- 7-50	4432	3397- 3414	L. Earlsboro sd; Penn.	P 20; 10 wtr.	....
Stephens		W. B. Davis' McKinley 1 (OWWO), sw sw nw 34-2s-6w.	6-12-50	2583	2475- 2500		P 25	36
Stephens		P. M. Harbour et al's Butts 1, nw sw nw se 34-2s-6w.	6-19-50	2525	1832- 1891		P 41	36
		OKLAHOMA—New Oil Pays						
Cleveland	Clothier, SW.	Midstates Oil Co's Trimble et al 1, se sw nw 29-10n-2w. 5 mi s of Moore.	6- 9-50	7500	6863- 6870	Misener sd; Miss.	F 175; 3/8"	42
Payne	Garr, S.	Woods Drilling Co's Burger 8, se sw se 17-19n-5e.	6-26-50	3885	3871- 3883	2nd Wilcox sd; Ord.	F 140; 3/8"	....
Payne	Markham, W.	W. H. Martgan et al's Coleman 1, ne se nw 8-18n-6e. ½ mi fr production.	6-21-50	3307	2976- 2978	Red Fork sd; Penn.	P 20	36
		OKLAHOMA—Oil Field Extensions						
Garvin	Maysville, SW.	Amoan Oil Cc's Hays 1, c sw nw 27-4n-3w. 1½ mi nw extension.	6-28-50	7322	7120- 7138	Gibson sd; Penn.	F 977; 11/16"	43
Grady	Knox	Ohio Oil Co's E. E. Harrison A-1, ne sw ne 29-3n-5w. ¾ mi sw extension.	6-25-50	3352	2790- 2796	Permian sd; Perm.	P 8; 24 wtr.	30.6
Jefferson	Ringling, N.	Amerada Petroleum Corp's R. A. Hefner 1, sw sw nw 4-4s-4w. 1 mi nw extension.	6-15-50	3200	2662- 2690	Hoxbar cgl; Penn.	F 203; 3/8"	32.2
Lincoln	Chandler	N. T. Smith & Smith Bros. Drilling Co's Ward 1, se se sw 35-15n-3e. ½ mi extension.	6-16-50	4490	4079- 4093	Prue sd; Penn.	F 5	26
Logan	Guthrie	Cities Service Oil Co's Koehn 1, ne se se 8-17n-1w. 1 mi e extension.	6-14-50	5487	4930- 4936	Skinner sd; Penn.	P 19	....
Major	Ringwood	Superior Oil Co's Coppock 1 (63-9), ne sw ne 8-21n-11w. 2½ mi w extension.	6-17-50	7220	6905- 6980	Manning sd; Penn.	F 15; 1/32"	....
Major	Ringwood	Superior Oil Co's Fuller 1 (63-30), ne sw ne 30-21n-10w. 4 mi w extension	6-18-50	7307	6985- 7045	Manning sd; Penn.	P 38	....
Noble	Longview, N.E.	Howell & Howell & Walter Duncan's Jirious 1, sw sw sw 31-24n-1e. 1 mi w extension.	6-18-50	4400	4303- 4369	Burbank sd; Penn.	F 190; 11/64"	42
Oklahoma	Munger, S.E.	Anderson & Pritchard's Lehmer 1, c ne ne 13-12n-2w, ½ mi s extension.	6-14-50	6220	5451- 5465 6082- 6094	Cleveland sd; Penn Red Fork sd; Penn.	F 0.7 mln. F 46	....
Pottawatomie	Maud	Davon Oil Corp's Wells Est 1, sw nw sw 5-8n-5e. ⅝ mi ne extension.	6-25-50	4135	4032- 4060	Misener sd; Miss.	P 25	....
		OKLAHOMA—New Gas Fields						
Marshall		Miller Bros et al's Otto Hill 1, se nw nw 17-6s-6e.	6-20-50	613	595- 613		F 2.5 mln.	....
Payne		Johnson Oil Refining Co's Shinn 1, se sw sw 12-17n-5e. 1 mi n of Happy Valley.	6-19-50	3450	3420- 3450	Bartlesville sd; Penn.	F 2.5 mln.	....
		TEXAS—District 1 (SOUTH CENTRAL)—New Oil Field						
Atascosa	"La Parita"	La Parita Oil Co's Tom Ventreck 1, 1000 fr nl 467 fr el of Tr. 1, Chupicks La Parita Subd, John Neal Sur. 5 mi sw of Jourdanton.	5-25-50	1535	1531- 1534	Carrizo sd; Eoc.	P 47	29
		TEXAS—District 1 (SOUTH CENTRAL)—New Distillate Field						
McMullen		Stanolind O&G Co's Hagist Ranch, Inc. 1, 330 fr sly sl 903 fr wly wl R. V. Allison Sur. 10 mi n of Freer.	6- 6-50	8021	7696- 7704		F 747; 34 mln; open	59.3
		TEXAS—District 2 (MIDDLE GULF)—New Oil Field						
Karnes	"Falls City, W."	Shell Oil Co's Ben Korzekwa 1, 330 fr sely nwl 2000 fr nel of Louis Manchacha Sur. 4 mi sw of Falls City fld.	5-18-50	6430	6257- 6264		P 81	37
		TEXAS—District 2 (MIDDLE GULF)—New Oil Pays						
Goliad	Weesatche	W. O. Woodward's Housman & Ranger 1, 660 fr nl 1320 fr wl of John T. Payne Sur.	6-21-50	5516	4756- 4766		F 275; 4/64"	39.6
Victoria	Minnita	Minnie S. Welder's Minnie S. Welder 6, 1757 fr nwl 7500 fr nel of Phillip Dimmitt Sur.	6- 5-50	5350	4354- 4358		F 58; 1/8"	....
		TEXAS—District 2 (MIDDLE GULF)—New Gas Fields						
Bee		Curtis Singleton Drilling Co's W. C. McCord 1 (OWWO), 330 fr ne&sel of P, Wilcox Sur. 6½ mi w of Beeville.	6- 7-50	1976	1961- 1976		3.8 mln; open	....
Victoria		E. C. Scurlock & M. S. Welder's Grace S. Henry et al 1, in 4-Lge Grant to town of Victoria. ½ mi s Victorial fld.	6-25-50	5365	3822- 3828		108 mln; open	....
		TEXAS—District 2 (MIDDLE GULF)—Gas Field Extension						
Bee	Unnamed	Curtis Singleton Drlg. Co's J. C. Robertson 1, 4500 fr nwl 3600 fr nel of James Stone Sur. 1 mi ne extension.	6- 6-50	1976	1952- 1967		33 mln; open	....

[1] Character of producing formations abbreviated thus: ch, chalk; dolo, dolomite; li, limestone; sd, sandstone; sh, shale; ser, serpentine; cgl, conglomerate. Ages of formation abbreviated thus: Plio, Pliocene; Mio, Miocene; Olig, Oligocene; Eoc, Eocene; U. Cre, Upper Cretaceous; L. Cre, Lower Cretaceous; Jur, Jurassic; Tri, Triassic; Perm, Permian; Penn, Pennsylvanian; U. Miss, Upper Mississippian; L. Miss, Lower Mississippian; Devo, Devonian; Sil, Silurian; Ord, Ordovician; Cam, Cambrian.

[2] Barrels of oil per day (24 hour rate), flowing (F), pumping (P), swabbing (Sw), or bailing (B); or million cubic feet of gas daily open flow capacity; size of choke given in inches.

LOOK AT THIS ECONOMY RECORD

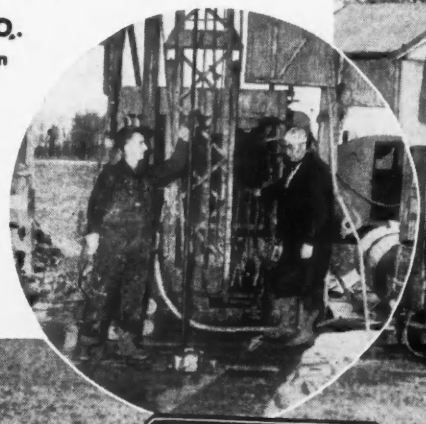
with a Bucyrus-Erie 28-L Spudder owned by Ford Oil Co., Holland, Michigan:

In 23 months of 24-hour operation — drilled 47 top-to-bottom wells averaging 1,500 ft. in depth, drove six carloads of 8-in. drive pipe — spent only $380 for repairs . . . *including* $200 for engine overhaul!

No wonder Glenn Mannes, owner of the Ford Oil Co. says "I like the machine 100%. Well satisfied!" "Drilling 47 wells in 23 months," he adds, "is remarkable for this part of Michigan where the general ground formations are drift and gray, green and brown shale." And you'll agree that a repair bill of only $380 for 23 months of 24-hour operation is a remarkable maintenance record — one that's hard to beat even in easy going!

This is the kind of economy, dependability, and output that has made Bucyrus-Erie spudders favorites among cable-tool men everywhere. Performance like this can make *your* drilling, well completion, or workover jobs pay bigger profit dividends. See your Bucyrus-Erie spudder distributor for all the facts!

BUCYRUS-ERIE CO.
South Milwaukee, Wisconsin



Pictured at the "business end" of the 28-L Spudder are owner Glenn Mannes (right) and operator J. B. Cheers.

70550

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BEACON SUPPLY CO. - - - Borger and Pampa, Texas
BECKWITH MACHINERY CO. - - - - - Bradford, Pa.
DRILLERS SUPPLY CO. - - - - - - - Joplin, Mo.
DRILLING & MINING EQUIPMENT CO. - Los Angeles 21, Calif.
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GROSS SUPPLY CO. - - - - - - El Dorado, Kan.
HAÛCO SUPPLY CO. - - - - - - Greensburg, Pa.
IVERSON SUPPLY CO. - Oklahoma City, Okmulgee, Tulsa, Okla.; Ft. Worth, Kermit, Odessa, Texas; Artesia, N. M.
LUCEY EXPORT LTD. - - Calgary and Edmonton, Alta.
THE McJUNKIN SUPPLY CO. - Charleston, W. Va.; Allen, Ky.
OLYMPIC SUPPLY CO. - - - - - - Seattle, Wash.
RANDALL-ZOGG SUPPLY CO. - Owensboro, Ky.; Princeton, Ind.
THE STRAKER SUPPLY - - - - - Mt. Pleasant, Mich.
TILLSONBURG PIPE & SUPPLY CO. - - Tillsonburg, Ont.
ZANESVILLE TOOL & SUPPLY CO. - Zanesville and Wooster, Ohio

New Oil, Distillate and Gas Fields and New Pay Horizons Discovered in the United States in June, 1950

Also Important Extensions to Established Fields

COUNTY	FIELD	COMPANY, WELL AND LOCATION	Date Completed	Total Depth (Feet)	Completion Horizon (Feet)	[1]Name, Character and Age of Producing Formation	[2]Initial Production Method and Choke	Gravity of Oil
		TEXAS—District 3 (UPPER GULF)—New Oil Pays						
Liberty	Esperson	John W. Mecom's General Crude 1, 3035 fr el 4960 fr wl of Dav.d Kokernut Sur.	6- 5-50	9954	9522- 9530		F 279; 5/32"	41.8
Liberty	S. Liberty	Texas State Drilling Co's Deussen 4, David Minchey Sur	6-26-50	3622	3396- 3496		F 115; 1/8"	22
Matagorda	Tidehaven	Hinkle Drilling Co's Mrs. Abel B. Pierce et al 1 (OWWO), 213 fr n&sl 125 fr el s½ Lot 4, Blessing Orange, Fig & Truck Fms Subd., J. Tilley Sur.	5-27-50	8907	8896- 8903		F 193; 11/64"	39
		TEXAS—District 3 (UPPER GULF)—Oil Field Extension						
Hardin	Nona Mills	General Crude Oil Co. et al's Kirby Lbr Co 2, 660 fr sly sl of H. G. King Sur. 1 mi sw extension.	6- 5-50	8522	8270- 8276		F 217; 1/4"	36.6
		TEXAS—District 3 (UPPER GULF)—New Gas Fields						
Wharton		Butcher-Arthur Inc's Albert Thomas 1, 3500 fr wl 3000 fr sl of John Bridges Sur. 4 mi n of Louise.	6-21-50	5658	4401- 4407		22 mln; open	
Wharton		J. B. Ferguson & Peter N. Petkas' Mrnustik et al 1, B. B. Pearce Sur. 5 mi ne of El Campo.	5-31-50	5344	5043- 5047		10 mln; open	
		TEXAS—District 3 (UPPER GULF)—New Distillate Field						
Hardin		American Republics Corp's O. C. Nelson Lge. 1, 2310 fr nl 1730 fr wl O. C. Nelson Lge. 8 mi ne of Silsbee.	6- 9-50	8000	7627- 7632	Yegua sd; Eoc.	F 50; 12 mln; open	50.2
		TEXAS—District 4 (LOWER GULF-S.W.)—New Oil Fields						
Duval	"Tiger"	Tiger Minerals Inc's W. R. Peters Est. 2-A, 303 fr wl 330 fr nl of 140-ac. lse, CB&CNRR Sur. 14 mi sw of Freer.	4-25-50	1734	1733- 1734		P 20	21
Nueces	"Jurica"	Train-Weisman's Ed Jurica Est. 1, 330 fr ne&sel of Lot 23, Sur 15. 3½ mi sw of Corpus Christi.	6-27-50	4856	4732- 4738		P 20	37
San Patricio	Triple "A"	J. S. & R. H. Abercrombie's A. E. Nelson 1, 592 fr sel 2204 fr swl of 287.18-ac Lse, Juan Garcia Sur. 2½ mi nw of Taft.	6-22-50	7471	6665- 6669		F 163; 5/64"	23.8
		TEXAS—District 4 (LOWER GULF-S.W.)—New Oil Pays						
Brooks	La Gloria	Fidelity O&R Co's A. A. Cosby 1 (OWWO), 660 fr ne&wl of Lot 4, Blk 5, Falfurrias Fm & Gar Trs. ½ mi nw of Falfurrias.	6- 1-50	9015	7240- 7248	Upper Atlee "A" sd; Olig.	F 46; 3/16"	44.3
Nueces	Chapman Ranch	The Chicago Corp's Chapman Ranch 1, 467 fr s&wl of Sect. 44, Laureles Fm Trs.	5-17-50	7750	7366- 7374		P 54	41
San Patricio	Portilla	Superior Oil Co's Minnie S. Welder 7, 3630 fr nl 990 fr el of Sect. 19, Welder Ranch Subd. C. J. Francisco & E. Portilla Sur.	6- 4-50	8850	7416- 7421		F 261; 5/32"	40
San Patricio	Sinton, W.	Grace Oil Co's Edward Trigg 6, 200 fr nwl 330 fr swl of 16-ac. Lse, Blk 23, John Pollan Lge.	6- 5-50	2800	2190- 2195		F 126; 11/64"	21
Starr	Frost	Sun Oil Co's A. Orive A-2, 467 fr s&wl of 100-ac. Lse, Porc. 97	6- 9-50	4158	4145- 4147		F 35; 1/8"	49
		TEXAS—District 4 (LOWER GULF-S.W.)—New Gas Fields						
Brooks		Humble O&R Co's Robert J. Kleberg, Jr. 3, 660 fr s&wl of T-M RR Sur. 7 mi ene of Encino.	6-13-50	10836	8622- 8635		No gge.	
Jim Hogg		Humble O&R Co's Eduardo Izaquirre, Jr. 1, 4200 fr wl 6500 fr nl of Tr. 1, Agua Nueva de abajo Gr. 8 mi nw of Santa Elena.	6-20-50	7500	7380- 7400		2 mln; open	
Kleberg		Humble O&R Co's King Ranch-E. Laureles G-4, 7260 s of Nueces-Kleberg Co. line, 15 mi s of Corpus Christi. Laguna Larga area.	6- 2-50	898W	6447- 6464		No gge	
Nueces		The Atlantic Ref. Co's W. F. L. Lehman 1-A, 660 fr sl 1980 fr wl lBk 25, Laureles Fm Trs. Ramon de Ynomosa Sur. 1 mi n of Chapman Ranch fld.	6-27-50	11005	9630- 9715		2.3 mln; 1/4"	
Nueces		The Chicago Corp. & Sullivan & Garnett's Jonas Well 1, 660 fr s&el of J. H. Gallagher Sur. 2 mi ne of Baldwin fld.	6-10-50	10205	9088- 9112		20 mln; open	
		TEXAS—District 4 (LOWER GULF-S.W.)—New Distillate Fields						
Jim Wells		Hickok & Reynolds Royalty Co's Reynolds & Richardson 1, 1000 n 180 e fr ne cor Richard Beasley Sur. 12, 7 mi se of Alice.	6-20-50	6200	3927- 3933		No gge; 11 mln; open	
San Patricio		Plymouth Oil Co's R. H. Welder G-1, 660 fr s&wl of Sect. 32, R. H. Welder Ranch Sbd.	6- 8-50	8279	6994- 7005		5; 0.2 mln.	60.6
		TEXAS—District 6 (NORTHEAST)—New Oil Field						
Titus		W. M. Coats & R. E. Moore's Josephine Chamness 1, 3325 fr nl 3300 fr wl of Allen Samuel Sur. 14 mi e of Talco.	6-18-50	4581	4571- 4575	Paluxy sd; Cre.	P 61; 162 wtr.	17
		TEXAS—District 7-C (WEST CENTRAL)—New Oil Fields						
Runnels		Robinson-Puckett, Inc. & G. W. Strake's S. H. Davidson 1, 330 fr s&wl of nw¼ Sect. 85, Blk 64, CTRR Sur, 3 mi nw Winters.	6-30-50	5055	3828- 3833	Palo Pinto li; Penn.	P 8	45
Runnels		Vincent & Welch, Inc's P. M. Davis 1, 1320 fr sl 330 fr el of Sect. 329, H&TC Sur. 2 mi ne of Winters, S. fld.	6- 5-50	3610	3585- 3610	Palo Pinto li; Penn.	F 219; 3/16"	43.7
		TEXAS—District 7-C (WEST CENTRAL)—New Oil Pay						
Runnels	Winters	Humble O&R Co's Bud Herndon 2, 467 fr el 4250 fr nl of Sect. 2, B. W. Taylor Sur.	6- 2-50	3964	2395- 2404	Gunsight li; Penn.	F 99; 1/4"	43.8
		TEXAS—District 7-C (WEST CENTRAL)—New Gas Field						
Runnels		O. W. Killam & Frank Pethybridge's J. P. Knight 1, 3492 fr el 2383 fr nl of Sect. 346, BBB&C Sur. 7 mi se Winters.	5-31-50	4376	3958- 3968	Strawn sd; Penn.	4.8 mln; 11/32"	
		TEXAS—District 7-C (WEST CENTRAL)—New Distillate Field						
Crockett		Magnolia Petroleum Co's Boyd Clayton 1, 1320 fr sl 1980 fr wl Sect. 12, Blk GH, GC&SF Sur. 10 mi e of Ozona.	6-13-50	9076	8680- 8730	Ellenburger li; Ord.	120; 9.2 mln; 24/64"	57
		TEXAS—District 8 (WEST)—New Oil Fields						
Howard		Stanolind O&G Co's Louis Hutto 1, 1160 fr sl 660 fr el of Sect. 4, Blk 31, T-1-S, T&P Sur. 2½ mi sw Coahoma.	6-10-50	9347	7370- 7430	Wolfcamp li; Perm.	P 27	35
Kent		Kewanee Oil Co's Wilson Connell 1-C, 1980 fr s&el of Sect. 3, Blk 4, H&GN Sur. 4½ mi nw Cogdell Canyon fld.	6- 9-50	6880	6853- 6870	Strawn sd; Penn.	F 329; 1/4"	38.2
Midland		Magnolia Petroleum Co's Roy Parks 2, 660 fr n&wl of nw¼ Sect. 10, M. C. Daugherty Sur. 11½ mi sw Midland.	6-30-50	12970	12955-12970	Ellenburger li; Ord.	F 785; 1/4"	54
Yoakum		Honolulu Oil Corp's Charles B. Towns 1 (OWDD) 660 fr n&wl of Sect. 382, Blk D, J. H. Gibson Sur. 13 mi e of Plains.	6-20-50	6770	6626- 6636	U, Clear Fork li; Perm.	P 106	27
		TEXAS—District 8 (WEST)—New Oil Pays						
Cochran	Landon	Stanolind O&G Co's Birtie T. Brown R/A "A" 3, 1353 fr nl 550 fr el of Sect. 14, Blk L, PSL Sur.	6- 1-50	11703	10120-10175	Bend sd; Penn.	F 292; 1/2"	39
Crane	Tucker	Jergins Oil Co's M. D. Self-State 2, 467 fr swl 165 fr nwl of Sect. 20, Blk 1, H&TC Sur.	5-26-50	5815	4167- 4173	L. Clear Fork li; Perm.	F 52; 1/2"	37
Midland	Sweetie Peck	General American Oil Co's Josie Faye Peck 1-D, 560 fr nl 838 fr wl of Sect. 21, Blk 41, T-4-S, T&P Sur.	6-22-50	12410	12215-12410	Devonian li; Devo.	F 611; 1/2"	48
Scurry	N. Snyder	L. H. Armer & G. H. Chizum's C. M. Lyons 1, 467 fr n&wl of nw¼ Sect. 119, Blk 3, H&GN Sur. 1½ mi e of production.	6-15-50	7504	7456- 7504	"C" Strawn sd; Penn.	F 389; 3/16"	37.5
		TEXAS—District 8 (WEST)—Oil Field Extensions						
Gaines	Hobbs, E.	W. H. Black Drilling Co's Edgar E. Jones 1, 660 fr sl 1980 fr wl of Sect. 5, Blk A-10, PSL Sur. ¾ mi nw extension.	6- 4-50	6435	5762- 5790	San Angelo sd; Perm.	P 174	35
Gaines	Russell-Devonian, N.	Shell Oil Co's Foster Petroleum Corp 1, 660 fr wl 662 fr nl of Sect. 492, Blk G, CCSD&RGNG Sur. 1 mi se extension.	6-13-50	11172	11045-11172	Devonian sd; Devo.	F 957; 3/4"	39.7
Kent	Salt Creek	Estill S. Heyser, Jr's L. T. Lohman, Trustee 2, 600 fr n&wl of Sect. 114, Blk G, W&NW Sur. 2 mi s extension.	6-15-50	6534	6474- 6515	Canyon Reef li; Penn.	F 547; 3/4"	39.8
Kent	Salt Creek	General Crude & Percy Jones' J. W. Young 1-144, 660 fr nl 330 fr wl of Sect. 144, Blk G, W&NW Sur. ½ mi se extension.	6-23-50	6467	6320- 6467	Canyon Reef li; Penn.	F 282; 1/4"	37.1
Kent	Salt Creek	General Crude & Percy Jones' J. W. Young 1-166, 1880 fr nl 1980 fr el of Sect. 166, Blk G, W&NW Sur. ½ mi n extension.	6-23-50	6498	6048- 6498	Canyon Reef li; Penn.	F 558; 1/4"	38.2
Midland	Tex Harvey	Morris T. Spencer's G. B. Leach 1, 660 fr s&wl of Sect. 3, Blk 37, T-3-S, T&P Sur. 1 mi n extension.	6-14-50	7342	7128- 7342	Sprayberry sd; Penn.	F 270	32
Scurry	Diamond-M	Ted Weiner et al's Moore Creek Missionary Baptist Church 1, 208 fr n&wl of Sect. 246, Blk 97, H&TC Sur. 1 mi nw extension.	5-17-50	6922	6840- 6870	Canyon Reef li; Penn.	P 33	43.1
		WYOMING—New Oil Pay						
Johnson	Sussex, S.E.	Continental Oil Co's Unit 15, se ne sw 15-42n-78w. 1 mi nw of production	6-22-50	7821	4604- 4642	Shannon sd; U. Cre.	Sw 20	

[1] Character of producing formations abbreviated thus: ch, chalk; dolo, dolomite; li, limestone; sd, sandstone; sh, shale; ser, serpentine; cgl, conglomerate. Ages of formation abbreviated thus: Plio, Pliocene; Mio, Miocene; Olig, Oligocene; Eoc, Eocene; U. Cre, Upper Cretaceous; L. Cre, Lower Cretaceous; Jur, Jurassic; Tri, Triassic; Perm, Permian; Penn, Pennsylvanian; U. Miss, Upper Mississippian; L. Miss, Lower Mississippian; Devo, Devonian; Sil, Silurian; Ord, Ordovician; Cam, Cambrian.

[2] Barrels of oil per day (24 hour rate), flowing (F), pumping (P), swabbing (Sw), or bailing (B); or million cubic feet of gas daily open flow capacity; size of choke given in inches.

Use of Shaped Charge Process for Open Hole Shooting

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FOLLOWING THE use of shaped charges in military operations, the principle was adapted to the shooting of the formation in wells, with the dual aim of producing flow channels immediately around the bore and of subjecting the zone to shock or impact which would tend to open channels along bedding planes. The author traces the development of shaped-charge shooting, and points out advantages which may be expected in the use of the shaped charge as contrasted to the use of bulk nitroglycerin in well-completion practice. The shaped charge is shown to be effective even when used in a cased hole, where the directed blast serves first to perforate the pipe and cement, and then to maintain a portion of its energy for work on the formation proper.

WITH the advent of shaped charge perforating, an entirely new concept in the field of open hole shooting was made available to industry. By shaping an explosive charge, the forces of detonation are focused at one particular point and therefore are utilized in a very efficient manner. Many of the limitations which have existed in the past have been overcome with the recent introduction of a new type gun.

This paper will discuss the applications of the shaped charge to open hole completions and will describe the appearance and performance of the various types of gun equipment used.

Open hole completions with casing set above the producing zone are generally considered in areas where the producing horizons are hard and are structurally able to support themselves. Completions of this type are also favored where rotary drilling muds might contaminate the pay zone and endanger its ability to produce. In such instances a short length of open hole is drilled below the casing shoe with cable tool equipment.

Prior to the introduction of the shaped charge process, well shooting in open hole was confined to the use of bulk explosives. Liquid nitroglycerin was favored because it explodes uniformly and produces extremely high shock pressures. Nitro shooting has sometimes been used effectively as a "last chance" possibility after all other production techniques have failed.

The general theory behind nitro shooting is to disrupt the formation by means of a veritable hurricane blast of hot expanding gases and to shatter the formation with the shock wave accompanying the blast. The bore hole is enlarged to several times its normal diameter and the structure is fractured or cracked along the bedding planes thereby establishing avenues for fluid drainage.

The shaped charge principle depends primarily on concentrating a portion of the explosive energy into a jet of gas which is capable of producing a deep cavity in the surrounding formation. The disruptive forces and shock wave are also present, as with nitro, but these forces are used in a supplementary manner to produce cracks and fissures around the shaped charge perforation. For a complete description of the mechanics involved in the shaped charge

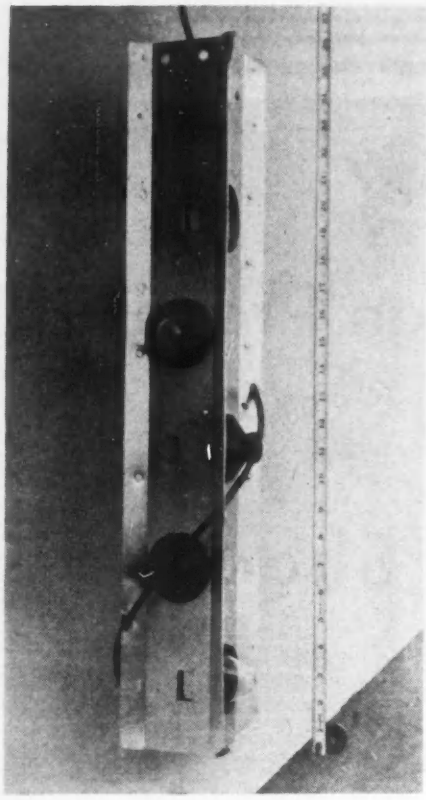

FIGURE 1. Early open hole gun design. Photo shows a short section of aluminum carrier containing glass lined charges. The primacord is housed within the steel tubing.

process, the reader is referred to items 1 and 2 of the bibliography.

A number of advancements have been made in the design of open hole gun equipment and each new design has contained significant advantages over its predecessor. Charges used for this type of work require more explosive than those used in cased hole perforating because of the compacted nature of formations and the fact that fracturing power, as well as penetrating ability, is a highly desirable feature.

The original shaped charge gun equipment for open hole use was tested in 1946. The shaped charges were packed in containers and assembled on a hanger in a series of 10 or less. The charges were fired electrically from the surface and promising results were obtained. This led to further experimentation and in 1948 a new design similar to that shown in Figure 1 was introduced. In this second design the charges were carried in boxlike sections built up of thin gauge aluminum alloy sheet and like its predecessor, the carrier was expendable.

In the second design no attempt was made to protect the charges from well fluids, hence several radical departures from conventional cased hole perforators were necessary. The jet effect was achieved by cementing 2 hollow glass cones together at their bases whereby one cone was used to form the liner for the explosive cavity and the second cone was used to provide the necessary air space for jet formation. The glass lined charges are shown in Figure 7.

Difficulty in transporting loaded carriers of this design was experienced making it necessary to load on the job.

During 1949, further improvements were made in the charge design. These later charges utilized improved metallic liners and greater amounts of explosive and were contained in pressure tight vessels such as illustrated by Figure 2. Deeper penetration, greater fracturing power and the ability to withstand higher well pressures were features of these charges.

As field experience was obtained with this type of equipment, it was possible to foresee further improvements which should be incorporated in any future developments. Some of these are as follows:

1. The charge should provide penetration equal to or better than that obtained with previous charges. It should withstand high external pressures and the container should have improved fragmentation characteristics.
2. The explosive components should withstand high well temperatures.
3. The carrier should have improved fragmentation characteristics, yet it should be more substantial in construction than previous types to facilitate measurement checks and normal down hole hazards.
4. The carrier should be such that numerous sections could be quickly coupled together, thus assuring flexibility in the number of shots per run.
5. The entire gun should be such that it could be safely transported to the job fully loaded, thereby reducing rig time to a minimum.

A gun design capable of meeting these specifications was completed late in 1949 and is illustrated by Figure 3. It is identified as the Type G gun.

By May, 1950, the "G" gun had been subjected to rigorous laboratory tests and was ready for introduction to the industry. The equipment is now available in most oil producing areas throughout the U. S.

Description of the Type G Gun

A reference to Figure 3 will show the type G gun equipment. The expendable carrier is made of cast iron and contains 7 charge assemblies located at 6-inch intervals and spaced 90 degrees angularly. The lower end of each carrier section will nest snugly within the upper end of a second section, thus making it possible to form multiple section guns of any practical length.

Two sizes of carriers are presently provided. The smaller measures 4¼ inch outside diameter and is used to run through 5½- to 6⅝-inch casing. The larger size measures 5⅝ inch outside diameter and is used to run through 7-inch casing and larger.

The charge assembly consists essentially of a cylindrical cast iron container closed on one end, a cartridge unit and a cast iron cap (Figure 4).

The cartridge unit is a packaged item with the explosive charge and metallic liner contained in foil sheathing. This unit was developed expressly for type G equipment.

Individual charge assemblies are held securely in the carrier by a simple locking means. The charges are contoured to match the contour of the carrier thus a smooth cylindrical section is maintained throughout the entire gun length. Placement of the primacord completely

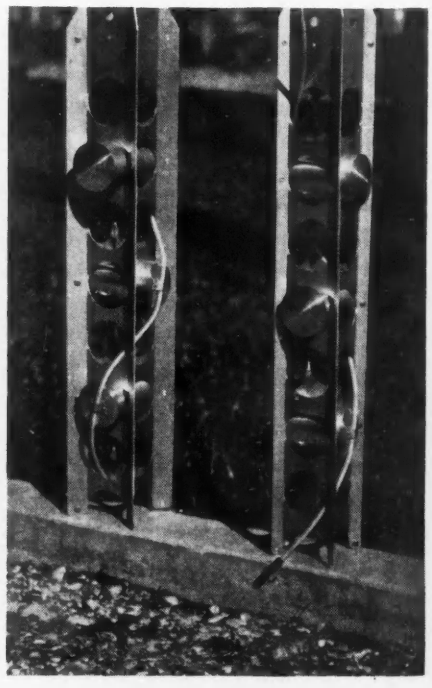

FIGURE 2. Aluminum carrier and improved type open hole charges. These charges contained the explosive and metallic liner in a pressure tight aluminum alloy case.

TABLE 1

CARRIER TYPE	Charge	Explosive	Penetration	Entry Hole	Remarks
4⅜" Sheet Alum.	Bakelite case glass cone	2 oz. low temp.	1.6"	½"	Early Design
5¾" Sheet Alum.	Bakelite case glass cone	5 oz. low temp.	1.8"	⅝"	Early Design
5⅜" Sheet Alum.	Alum. case metallic liner	5.8 oz. low temp.	5.5"	⅞"	Improved Charges
4¼" Cast Iron	Cast iron case metallic liner	4 oz. high temp.	5.1"	¾"	Type G Gun
5⅝" Cast Iron	Cast iron case metallic liner	6½ oz. high temp.	6.4"	⅞"	Type G Gun
5" Std.	34A	1 oz. high	5.5"	⅝"	5" Casing Perforator

within the carrier so as to form a smooth spiral from charge to charge was an important improvement. This feature eliminated the possibility of damage to the cord while running the carrier in the well. It also resulted in the important advantage of maintaining a minimum primacord length between the charges. A short primacord length permits the closest spacing between charges without interference effects and resultant loss in penetration.

In service company operations, the carriers are transported to the job fully loaded but not armed. On location the individual carrier sections are coupled together as desired by the operator and the gun is armed with a blasting cap.

The charges are initiated by transferring the detonating force of high density primacord through a solid bulkhead in the charge case. Booster charges are presently used on either side of the bulkhead to assure that the charges are properly detonated under all well conditions (Figure 4).

Normal rigging procedures and standard hoisting equipment are used to run the gun.

Tensile tests show that the 4¼-inch carrier will resist a force in excess of 2000 pounds. Since loaded carriers weigh only 35 pounds, it is apparent that the dead weight of the gun will not be a limiting factor in the number of sections that can be coupled together. At the time of writing, 5-section guns have been used successfully and there is every indication that even larger guns can be used if required.

Performance Characteristics

1. Penetration

Penetration data for open hole shaped charge equipment have been obtained in terms of steel plate penetration. These tests are conducted in two ways.

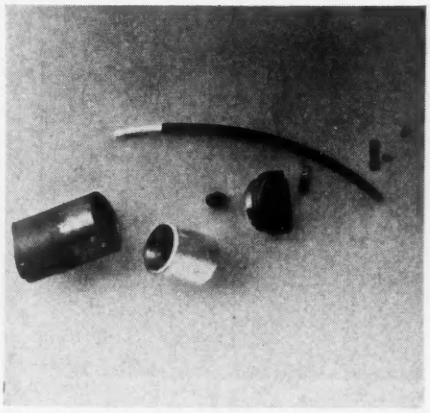

FIGURE 4. Components of type G charge, cast iron container, cartridge unit and cast iron cap. Capsule and cylinder by cap are booster charges. Primacord is in heavy wall rubber tubing.

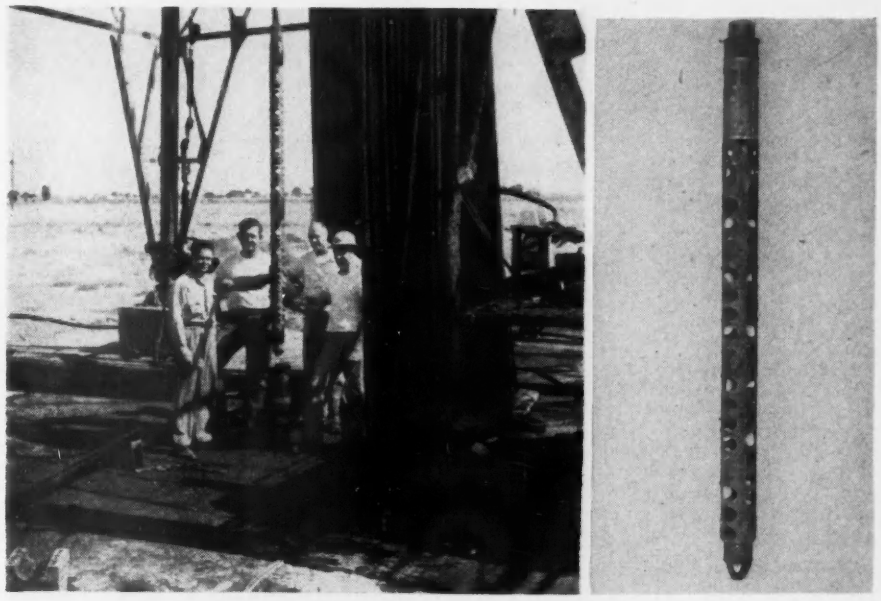

FIGURE 3. A (Left), two-section gun ready to be run in the well. B (right), closeup of two-section gun showing charges in place. Primacord is housed in rubber tubing and is contained completely within the carrier.

(a) Static or Single Shot Tests
In these tests the charge is positioned in air a representative distance away from a stack of steel blocks. Figure 5 is an example of a static test setup.

(b) Dynamic Tests
Multiple shot tests where a full gun is positioned within a fixture containing stacks of steel bars such as shown by Figure 6. Multiple shot tests are generally conducted with the gun and fixture submerged under a low fluid head.

Steel plate penetration tests are useful for studying the relative penetrating ability of various shaped charge gun designs. The information obtained does not bear a fixed relationship with the penetration obtainable in non-homogeneous targets. The steel plate penetrating ability of the various open hole gun designs fired statically is illustrated by Table 1. A pictorial representation of this data is shown in Figure 7.

2. Fragmentation

Field experience and laboratory tests reveal that sheet aluminum carriers do not fragment well and in some cases the larger pieces have caused difficulty during cleanout operations. It has also been found that charge cases made from aluminum do not possess outstanding fragmentation characteristics.

Proper fragmentation is a very important characteristic of open hole equipment. Since one of the reasons for using shaped charge equipment is to reduce cleanout time, it is imperative that the material be well broken up to facilitate bailer or sand pump operations. A second and perhaps even more important consideration is the impinging effect which properly fragmented material has when bombarding the formation walls at ultra high velocities.

After careful consideration of many materials, cast iron was chosen as the best for all structural parts of the type G gun. Carriers and charge containers made from this material have the advantages of excellent frangibility coupled with good strength characteristics. The density of cast iron affords another advantage in that no additional weight in the form of sinker bars is usually required.

Figure 8 shows the debris recovered in fragmentation tests using both aluminum and cast iron carriers. This debris is the result of firing 4 complete cast iron carriers and a short section of one

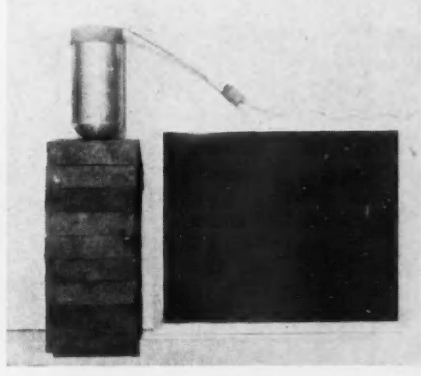

FIGURE 5. This photo illustrates static test setup, showing charge in position for firing. The distance between the charge and the top block is varied to simulate various well bores.

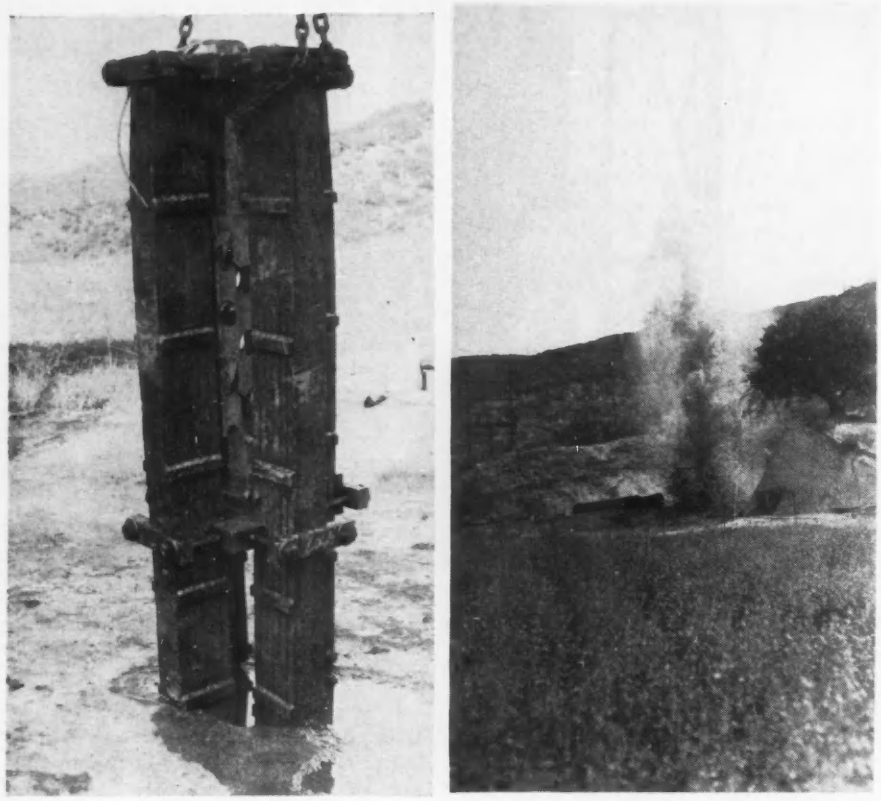

FIGURE 6. A (left), Test setup showing an experimental gun design in position for multiple shot penetration test. Magnitude of the explosive force is illustrated by the bowing of the steel bars. B (right), Typical surface reaction when firing multiple shot tests under a low fluid head.

aluminum carrier. The marked pieces may be identified as follows:

A. Largest cast iron piece recovered, 2 x 3 inches
B. Typical large cast iron fragments.
C. Typical small cast iron fragments.
D. Typical fragments of sheet aluminum carrier. Largest piece approximately 5 x 5 inches.

Elevated Temperatures and Pressures

A discussion of the effect of temperature and pressure must be made on the basis of the combined effects of these variables as well as their single effect.

Temperature alone is not a serious problem and may be controlled by the use of so-called "high temperature explosives." These explosives are capable of withstanding temperatures as high as 350° F. and are used in the type G gun.

Pressure alone may act to reduce the sensitivity or brisance of exposed explosive components. In the G gun the explosive charge is contained in a sealed container and is not subjected to pressure forces. However it is known that the collapse of the charge container due to external pressure will cause the charge to be detonated. This condition is serious and the charge container must be capable of providing an adequate safety factor under all well conditions. The cast iron container used in the G gun has been tested to fluid pressures in excess of 12,000 pounds per square inch.

The combined effects of temperature and pressure manifest themselves at points where it is necessary to transfer the detonating force of one explosive

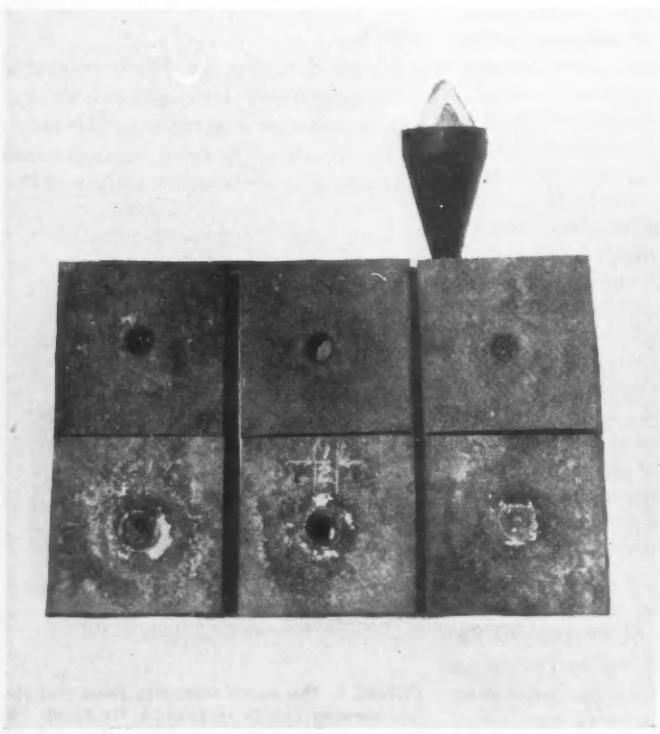

FIGURE 7-A. 2-ounce glass lined charge.

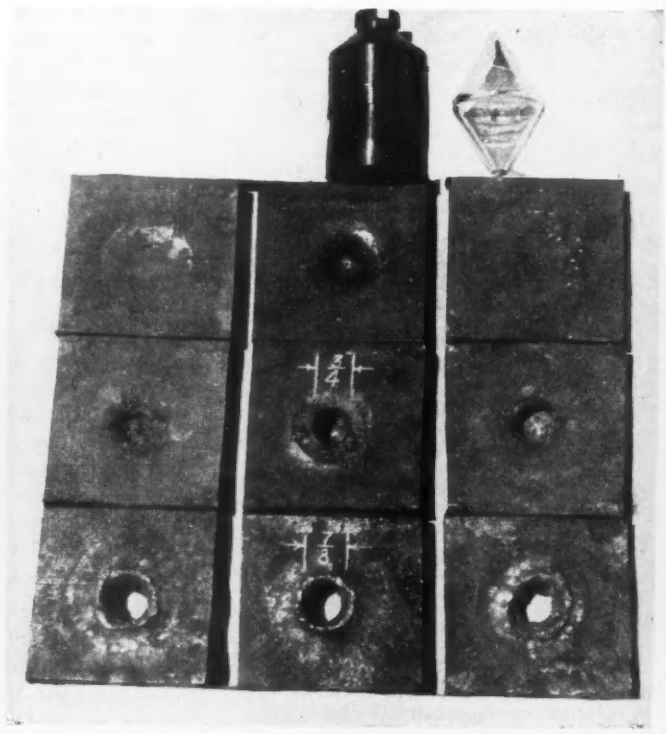

FIGURE 7-B. 5-ounce glass lined charge.

component to initiate a second explosive component. Such places are found in open hole equipment at (1) the juncture between the primacord and each individual charge and (2) the primacord splice between carrier sections.

Well pressure forces acting at juncture points tends to squeeze the primacord explosive and produces a "dead pressed" condition. The explosive when dead pressed loses much of its brisance or detonating force and tends to be desensitized if high well temperatures are also present. These difficulties have been overcome through the use of properly designed components at each critical point and the G gun can be operated under temperature conditions up to 280° F. and at pressures in excess of 8000 psi.

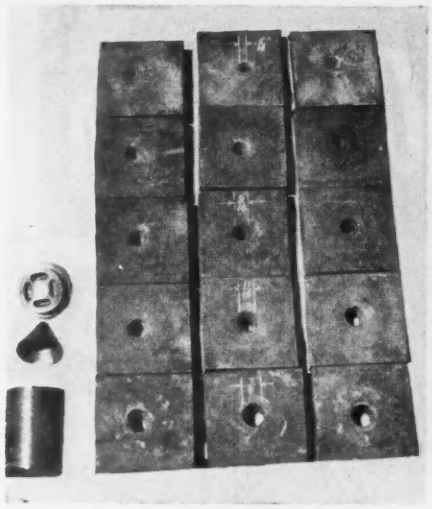

FIGURE 7-C. 4¼-inch type G charge.

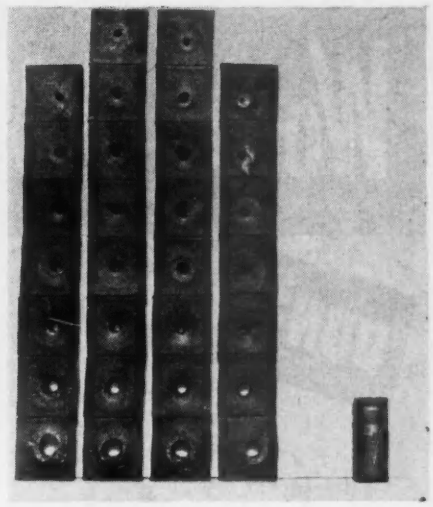

FIGURE 7-D. 5⅝-inch type G charge.

Conclusions

Aside from the purely theoretical advantages which may be claimed for the open hole shaped charge equipment, there are several features which are well established and worthy of further comment.

1. **Safety**—The explosives used in the type G gun are considerably less dangerous to handle than nitro. Any explosive regardless of its classification represents potential danger. However, some explosives are inherently less sensitive than others and therefore safer to handle.

2. **Zone Coverage**—Any length of zone can be covered with open hole shaped charge equipment in a minimum of time. With the type G gun equipment it is possible in many cases to cover the complete zone in one run.

3. **Cleanout Time**—Experience has shown that considerably less cleanout time is required with this method than with nitro. This is due primarily to the fact that the explosive forces are controlled to produce maximum penetration into the formation but a minimum amount of caving or sloughing of the walls. Normal cleanout times based on an average of 10-20 shots will require approximately 2-4 hours with the sand pump.

4. **Temperature**—Nitroglycerin begins to decompose at approximately 140° F. and consistent results cannot be expected at temperatures above this. It is sufficient to say that the shaped charge process will function satisfactorily at temperatures approximately twice as great as those at which nitro can be used.

5. **Miscellaneous**—Open hole shaped charge shooting has proven to be useful in limestone areas which respond to acidizing. Instances are recorded where the open hole formations required extremely high pressures for breakdown and treatment prior to shooting the well with shaped charge equipment. After shooting, the breakdown pressure was reduced to less than 1000 psi.

Some operators are using the equipment in cased portions of the hole. In these instances the operator is always cautioned regarding the potential damage which may result to the casing. However, good results have been obtained where unusually heavy cement and mud sheaths must be penetrated. Casing damage in most cases has not been excessive.

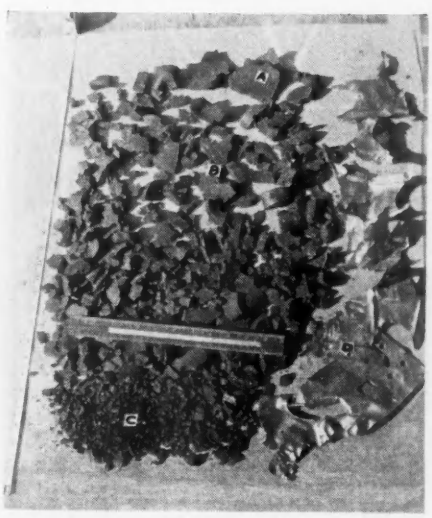

FIGURE 8. Fragmentation characteristics of cast iron and aluminum type carriers. Refer to text for full explanation.

About the Author

JOHN T. GARDINER was graduated from the University of Nevada in 1939 with a B.S. degree in mining engineering. After working in various capacities in the mining industry, he joined Lane-Wells Company in 1944 as a production engineer. Since 1946 he has been employed with Lane-Wells in the capacity of field service engineer.

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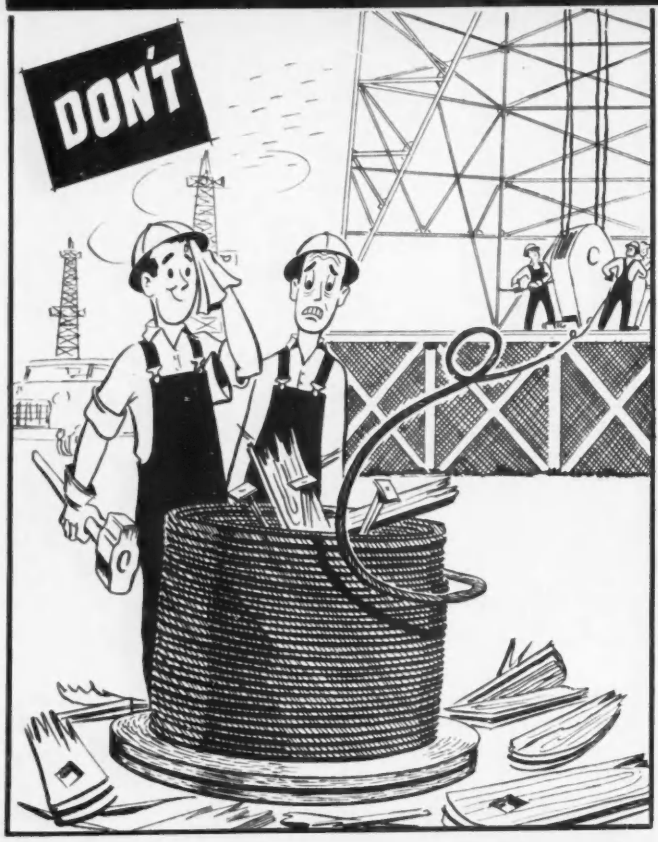

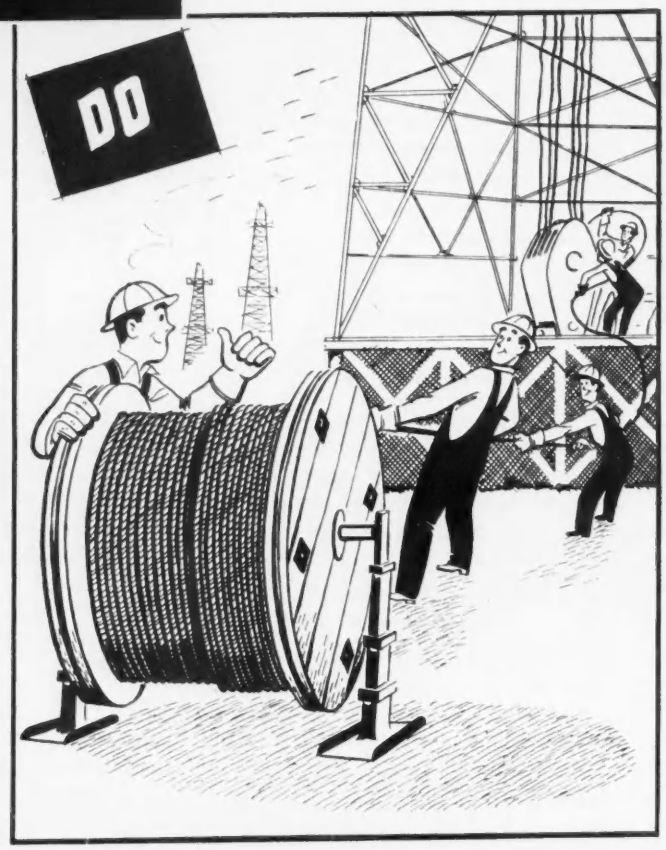

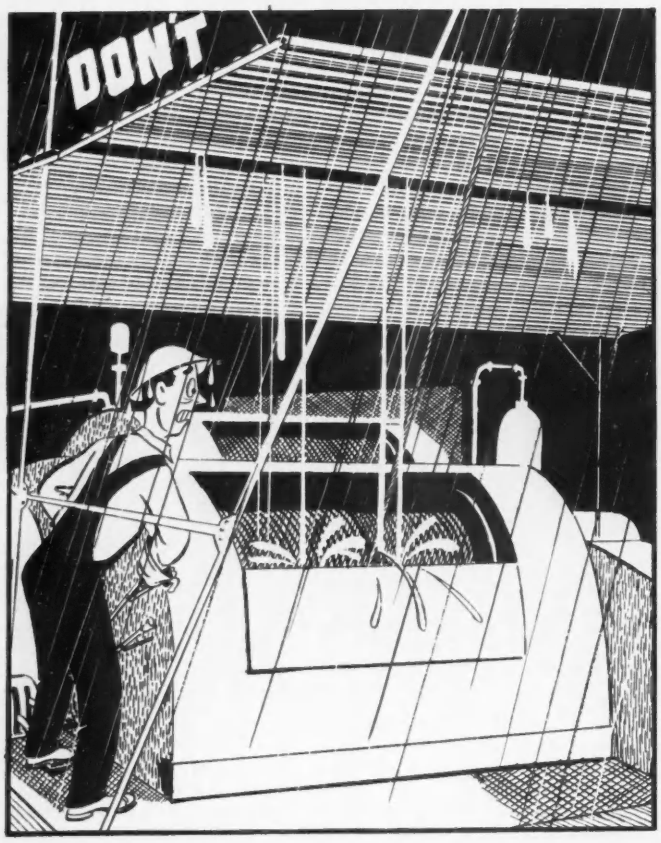

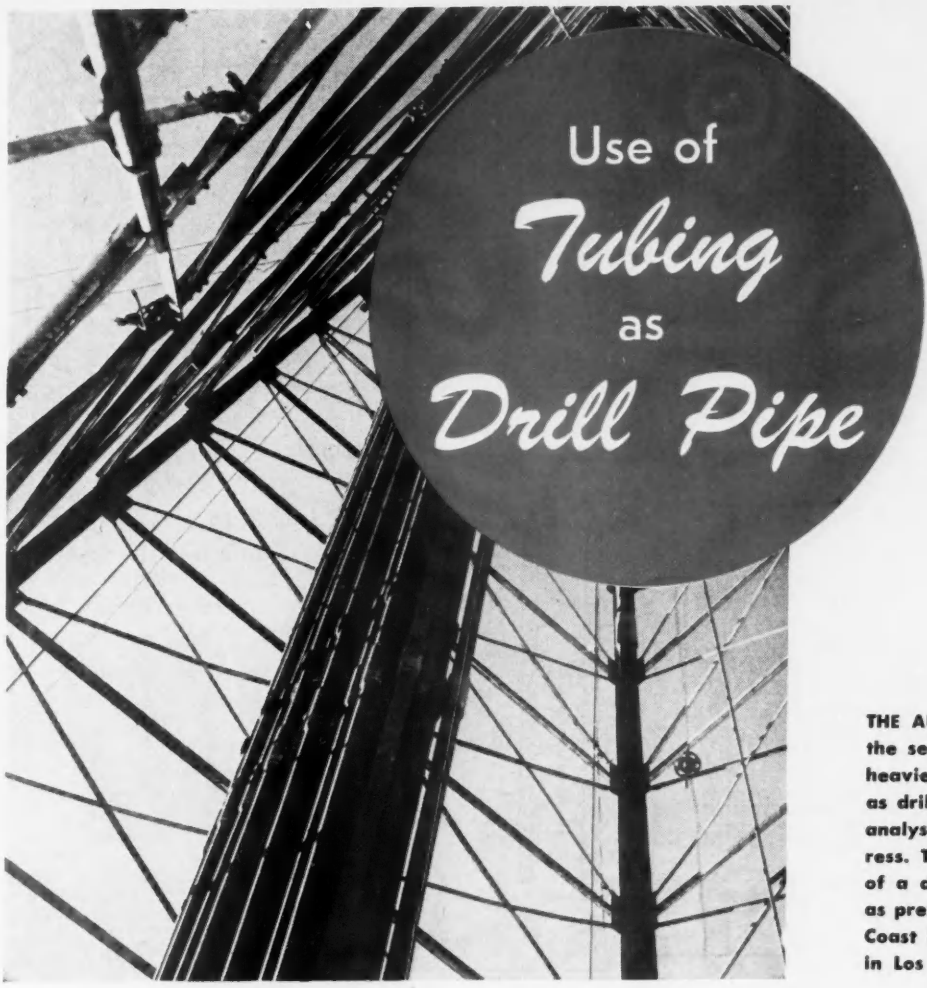

Use of Tubing as Drill Pipe

By W. F. BATES
Shell Oil Company

THE AUTHOR discusses considerations given to the selection of lightweight tubing in place of heavier drill pipe. Cases where tubing was used as drill stem are reported, as well as detailed analyses of comparable drilling costs and progress. The paper is printed, with the exception of a detailed table on 39 wells, substantially as presented before the Spring Meeting, Pacific Coast District, API Division of Production, held in Los Angeles May, 1950.

AS AN integral part of the continuous effort to reduce well costs, the Pacific Coast area staff of Shell Oil Company undertook a study of slim hole drilling. These studies were conducted to determine optimum hole and drill pipe sizes and included such factors as circulating rates and pressures, mud flush, rising velocity and availability of suitable sidewall sampling, fishing and testing tools. Because theoretical and practical considerations were strongly in favor of the 6¾-inch hole using 3½-inch drill tubes, this combination was accepted as a basis for slim hole operation.

Studies of possible drilling units that could be moved legally over California highways led to the conclusion that equipment designed to handle 10,000 feet of 3½-inch drill pipe did not exist and furthermore that it was extremely unlikely such equipment could or would be built for some time; however, it was recognized that existing portable equipment could be used to drill deeper if the drill pipe loads could be reduced. Further studies along this line, which included a review of experience with Acme-thread drill casing used for drilling in the Ten Section field, led to the selection of 9.3-pound, 3½-inch upset J-55 API tubing with Acme-type threads for the drilling of 6¾-inch slim holes.

A portable drilling unit powered with a 150-horsepower diesel engine was available for testing the practicability of using tubing for drilling and it was reasoned that as this unit could successfully handle loads equivalent to 3500 feet of 4-inch, 16.6-pound drill pipe, its depth range could be extended to 6500 feet through the use of 9.3-pound tubing as drill pipe.

The selection of 9.3-pound tubing was based primarily upon availability of an API standard tube plus the fact that 2½-inch tubing had been successfully used in "drilling in" operations in the Ten Section field. Therefore, it was believed this tubing would have the ability to transmit the necessary torque required for rock bit drilling. "J" grade tubing was preferred over "N" grade as it has more resistance to shock as indicated by elongation specifications.

Acme-type threads were selected because they had been used so successfully in our drill casing operations in the Ten Section field and also because this type of thread could be obtained without waiting for the manufacture of special joints. Also, it was believed that an inexpensive tool joint such as a tubing collar, if it could be used, would contribute materially to the economic success of slim hole drilling. As experience with drill casing had definitely proved (a) the desirability of using power tubing tongs to spin up the pipe as it is run in the hole, and (b) the necessity of using specially built tong jaws which would evenly distribute over a large area the crushing force developed while breaking out the tubing, this equipment was obtained before starting the drilling test.

As circulating rates and pressures were expected to be well within the rating of the pumps normally used with the 150 horsepower drilling unit, no alterations or additions were made to this equipment.

Area "A" in the San Joaquin Valley was the location for our initial tubing-

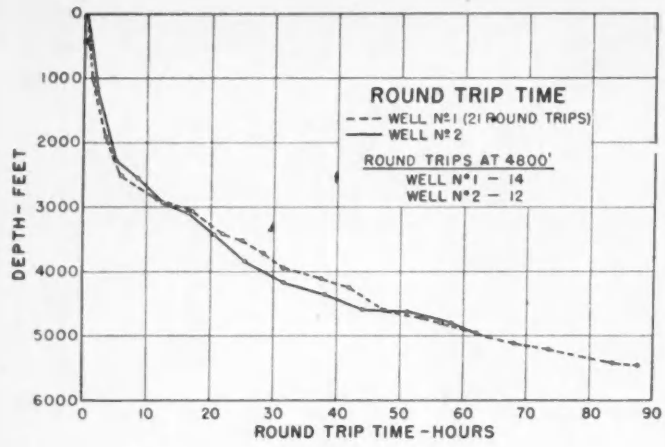

FIGURE 1

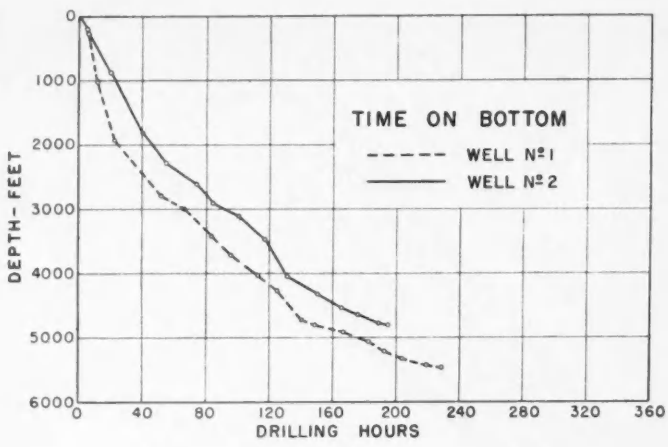

FIGURE 2

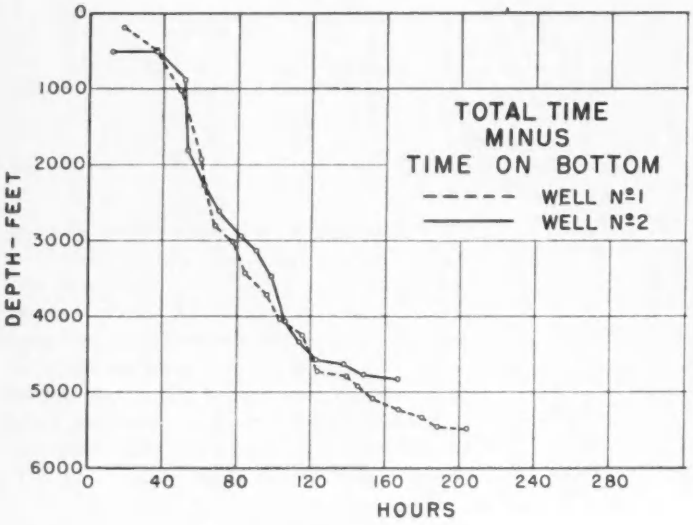

FIGURE 3

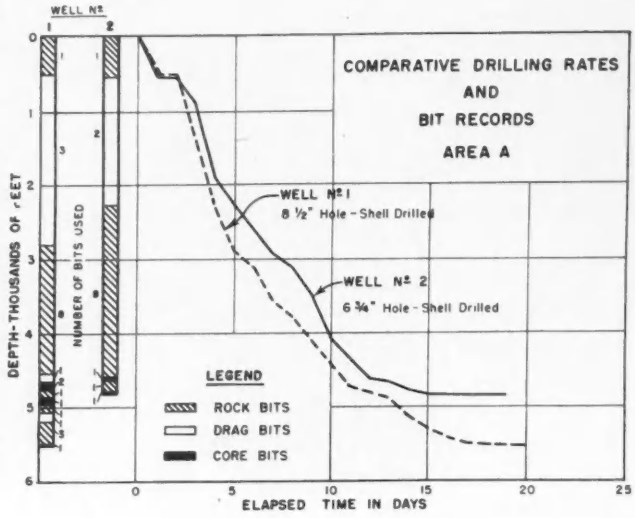

FIGURE 4

drilled hole. A conventional well had been drilled in this area in 1945 which it was believed would offer a yardstick for comparing progress. The tubing-drilled hole was completed in 1946. A detailed cost comparison indicated that when allowances were made for the estimated rise in material and labor costs, the saving was about $2 per foot, or about 30 percent.

In addition to this favorable cost comparison, a study of other factors such as round-trip time (Figure 1), time on bottom (Figure 2), total time minus time on bottom (Figure 3), drilling rates and bit records (Figure 4), as well as a comparison of various percentages of total time (Figure 5) indicated that the slim hole and lightweight pipe combination was comparable to the large hole and heavy pipe combination.

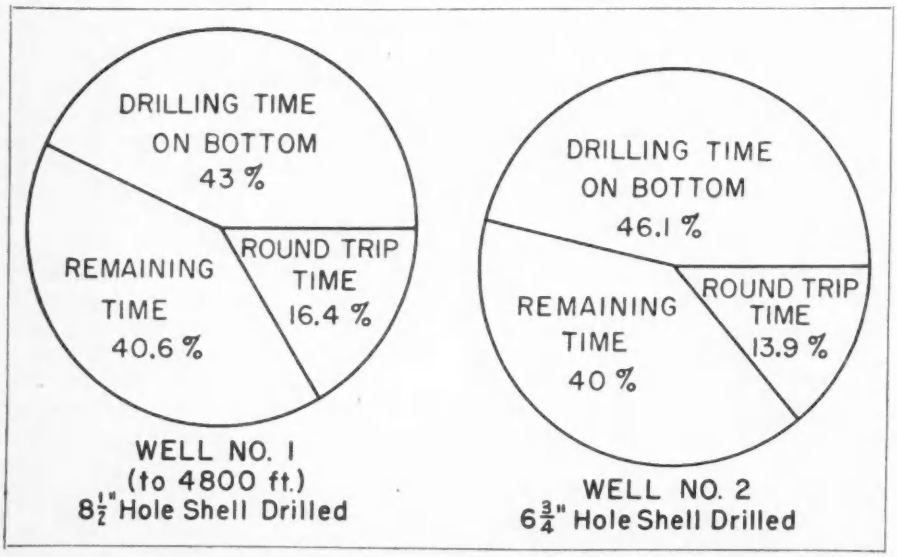

FIGURE 5. Comparison of various percentages of total rig time.

Although direct well cost comparisons are exceedingly unreliable, it is fortunate that since the drilling of the initial tubing-drilled hole in 1946 there are 4 other areas in which detailed cost comparisons can be made. In 2 of these areas only 1 tubing-drilled hole and 1 large hole were drilled. In another area, 5 wells were drilled; 2 of these wells were drilled by contractors and the other 3 by Shell using 3½-inch tubing as drill pipe. In the remaining area, 8 wells were drilled of which 3 were tubing-drilled holes, and the other 5 were drilled with contract tools using 4½-inch drill pipe and drilling an 8½-inch hole.

Even in areas known to be fairly comparable in drilling rates, it is difficult to compare well costs directly, particularly in wildcat or semi-wildcat drilling. This is further complicated by the rapid increase in material and labor cost

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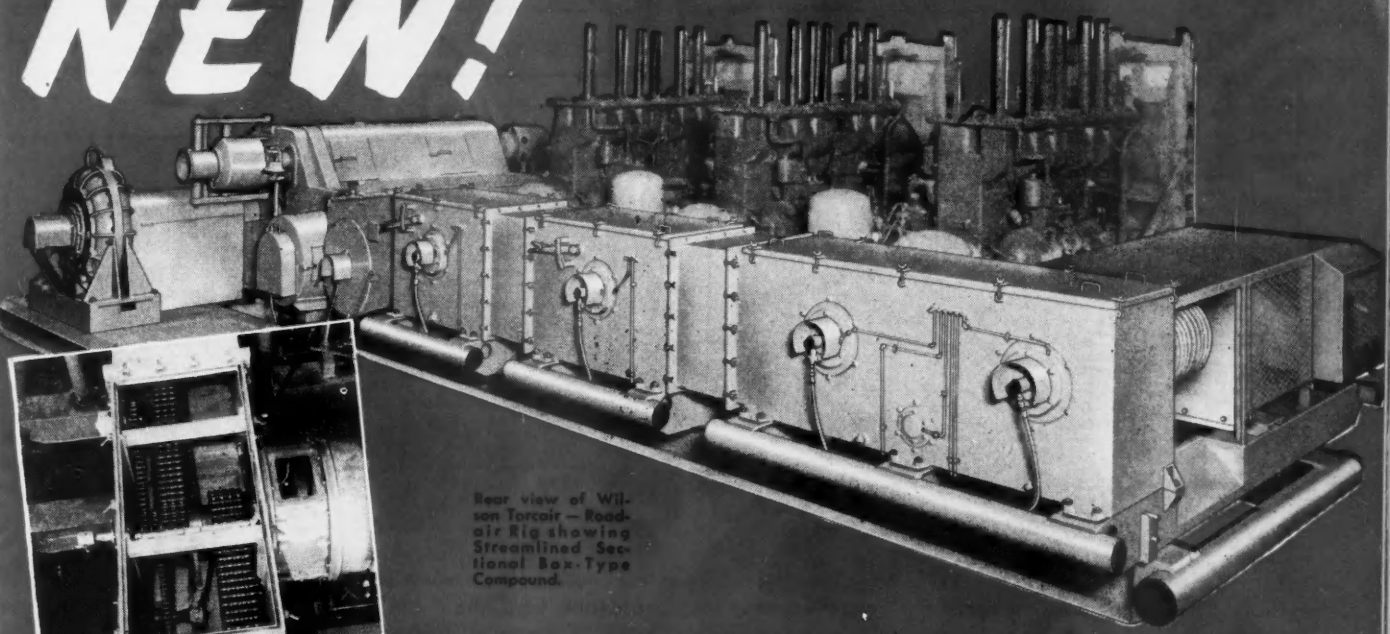
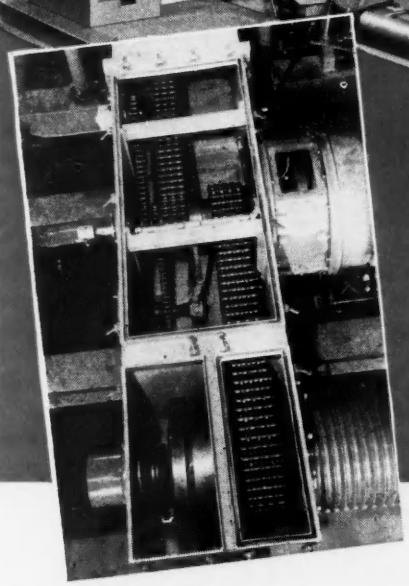


Rear view of Wilson Torcair — Roadair Rig showing Streamlined Sectional Box-Type Compound.



Top view of Sectional Compound with oil tight lids removed.

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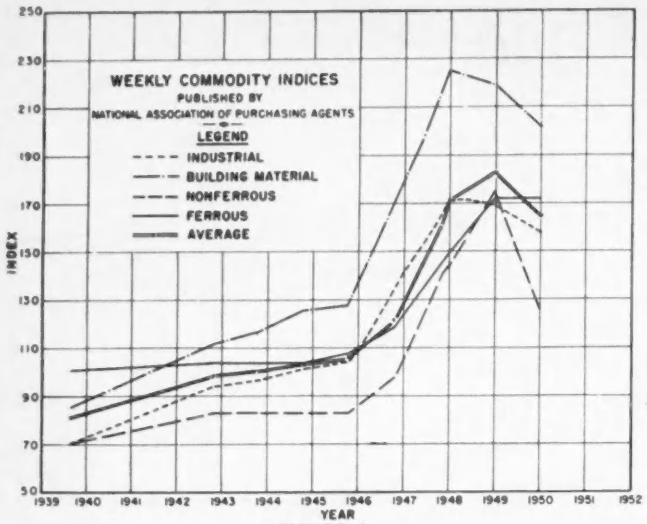

FIGURE 6

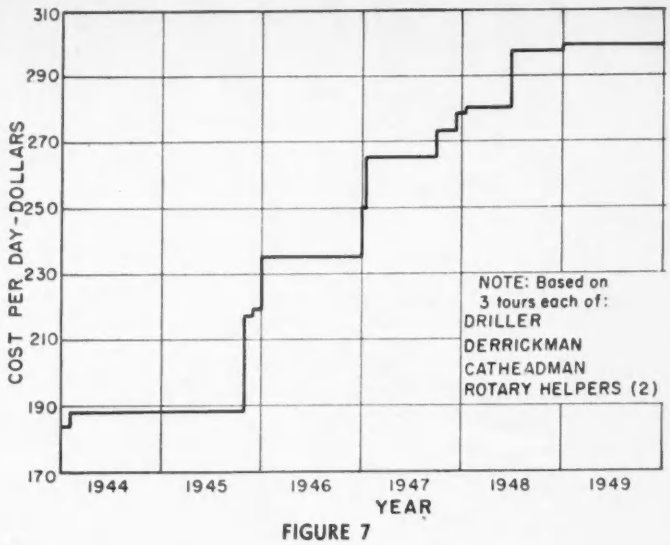

FIGURE 7

which took place in 1945, 1946 and 1947. An attempt has been made to compare costs through the use of a commodity index chart (Figure 6). This chart, prepared with the aid of the Purchasing department, must be used with caution, as no attempt was made to ascertain the exact percent increase of detailed items. However, each accounting classification was analyzed for percent of tangible material cost and applicable commodity index and an adjustment made. All intangible costs including outside labor were adjusted in accordance with the labor index chart (Figure 7). Costs are adjusted only for the time increment from the drilling of the first to the last well in any one group. In this manner, it is believed that a truer difference in cost of tubing-drilled hole versus conventional hole is obtained. Table 1 gives an example of the technique employed to analyze and adjust costs in accordance with the commodity indices.

TABLE 1
Adjustment of Costs According to Commodity Indices
Area "E"—Well No. 12; Date Completed: 2-5-46; Total Depth: 5528 Feet

ITEM	Total Cost (Dollars)	Index Used*	INDEX VALUES		Increase (Percent)	Adjusted Cost (Dollars)
			At Date of Drilling Well	At Date of Last Well Drilled In Group		
Labor	86,717	W	235	285	21.2	105,101
Service Facilities	401	A	111	161	45	581
Tool Rental	292	A	111	161	45	423
Drilling Materials and Supplies	7,243	A	111	161	45	10,502
Rig Foundation	306	B	134	214	59.6	488
Cementing Material	1,057	B	134	214	59.6	1,687
Mud Material	4,065	N	88	139	51	6,138
Casing	7,335	F	112	132	30	9,536
Production Equipment	3,440	F	112	132	30	4,427
Totals	110,856					138,928
Cost per Foot	20.05					25.10

* Indices according to Fig. 6:

A—Average
I—Industrial
B—Building Material
N—Non-Ferrous
F—Ferrous
W—Wages (crew costs) in accordance with Fig. 7

TABLE 2
Recapitulation of Costs of Wells Drilled in Area "E"

Well No	Hole Size (Inches)	Cost Per Foot (Dollars)	Adjusted Cost (Dollars)	No. Days Abandoning (After reaching deepest depth)	Casing Size (Inches)	Contract or Shell	Completion Date	Tubing or Drill Pipe (Inches)
Abandoned Wells (No Casing)								
18	6¾	5.48	5.65	2	..	S	8-18-47	3½ T.
17	8½	10.68	11.40	7	..	C	7-11-47	4½ D.P.
Abandoned Wells with Casing								
16	8½	14.09	14.70	12	5½	C	6- 9-47	4½ D.P.
Completed Wells				No. Days Completing				
12	8½	20.05	25.10	36	5½	C	2- 5-46	4½ D.P.
13	6¾	10.48	12.95	12	4¾	S	10- 4-46	3½ T.
14	8½	14.44	15.13	23	5½	C	3- 3-47	4½ D.P.
15	8½	12.23	12.80	8	5½	C	4-25-47	4½ D.P.
19	6¾	9.94	9.94	17	4¾	S	10-12-47	3½ T.

The wells drilled in Area "E" offer the best comparative data as they are the most numerous as well as the most recent. Again caution must be exercised in directly comparing these adjusted well costs because in some instances wells were abandoned without setting casing while others were abandoned after setting casing and still others were completed as producing wells. Additionally, various numbers of days were consumed in making tests before completing or abandoning.

A recapitulation of the wells drilled in Area "E" necessitates their division as shown in Table 2. This recapitulation indicates that wells drilled in this area with Shell tools using tubing as drill pipe saved an average of about $6 per foot. It should be stated that Well 15 was a consecutive well for the contractor, whereas Shell Well 13 was the first Shell-drilled well in the area and required moving equipment about 400 miles.

Also of interest is the average comparable daily operating cost in this area for the small rig using tubing as drill pipe and a larger contract rig (adjusted for wage and material differences by multiplying actual daily operating cost times percent increase of average commodity indices as plotted in Figure 6), the former being $767 per day and the latter $1647 per day, or a difference of $880 per day. For comparative purposes this difference should be reduced by $110 per day as tool depreciation is not included as a cash operating cost on Shell rigs.

As a further check on tubing-drilled holes, the daily rate of progress for each well was plotted by areas (Area "B"—Figure 8, Area "C"—Figure 9, Area "D"—Figure 10, Area "E"—Figure 11). Area "E" again offers the best data. It is extremely interesting to note that in this area a 6¾-inch tubing-drilled hole penetrated to the area's comparable depth of

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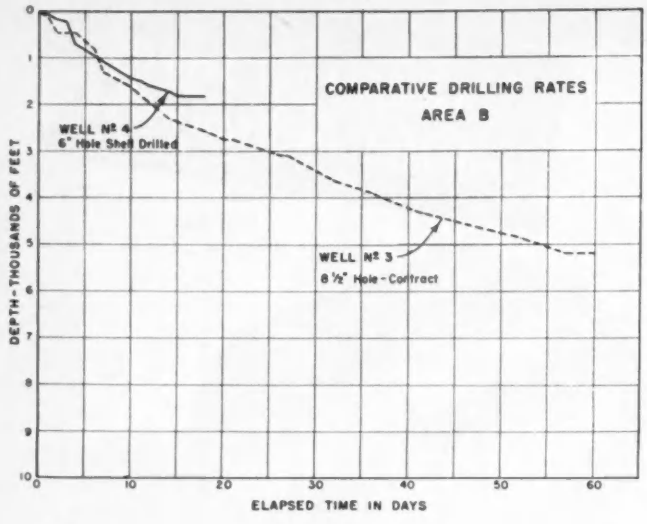


FIGURE 8

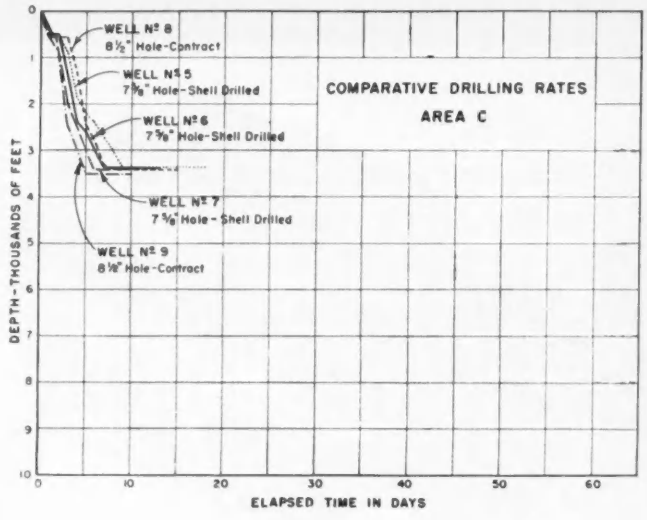


FIGURE 9

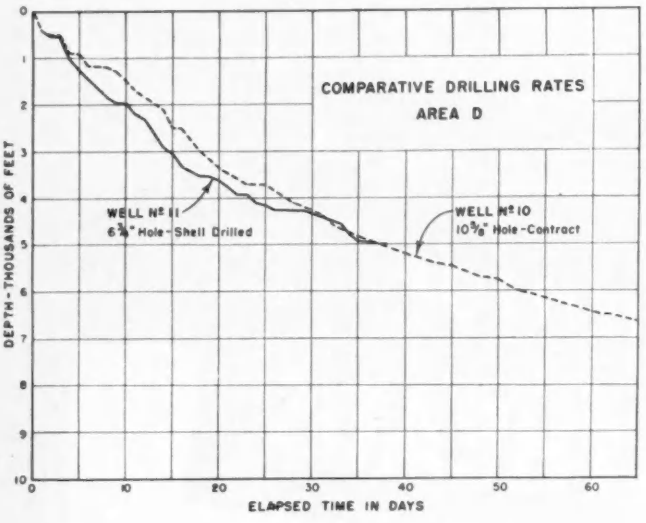


FIGURE 10

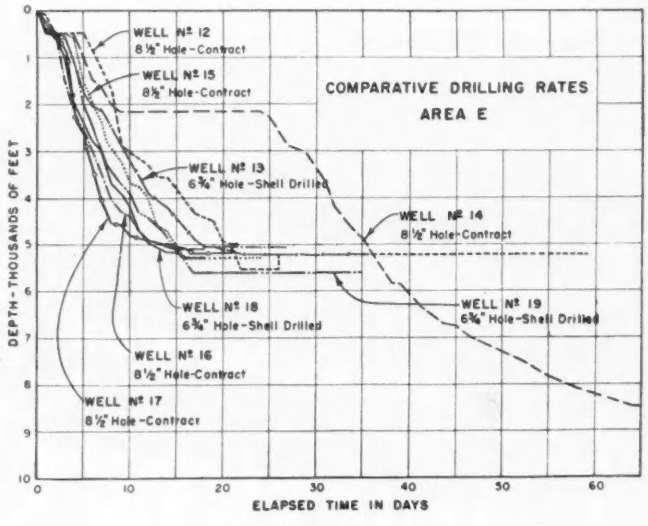


FIGURE 11

5118 feet in 14 days. Three other wells reached this depth in 15 days, one of which was a tubing-drilled hole. In 17 days another 8½-inch hole reached this depth followed by a tubing-drilled hole in 20 days, the latter being the first tubing-drilled hole in the area. The 2 holes which made the slowest progress were 8½-inch in diameter; one was the discovery well and the other had a 15-day fishing job.

A recapitulation of adjusted well costs in the other two comparable areas is shown in Table 3.

Differences in depths of the wells in Area "D" make direct cost comparisons difficult but it is of interest that the tubing-drilled hole reached its maximum depth of 5000 feet in 37 days at a daily operating charge of $860 whereas the conventional hole reached 5000 feet in 37¼ days with a daily operating charge of $988 ($1300 adjusted).

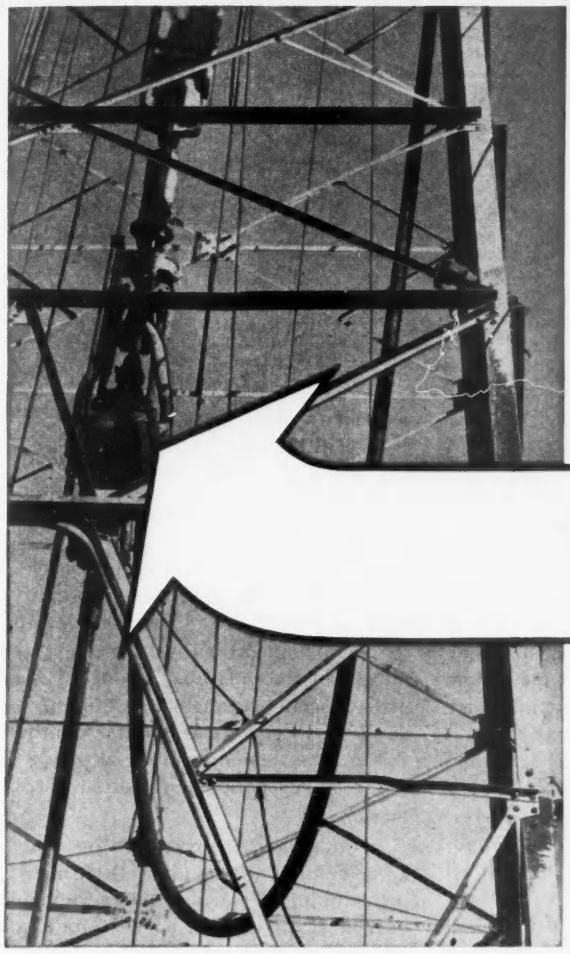
Adverse weather encountered in drilling the first tubing-drilled hole in Area "C" (Well 5) resulted in its cost being higher than normal.

Before starting the deep well, a 16,920-foot string of 3½-inch Acme-thread drill tubing with collars was purchased at a cost of $12,819, or about $0.755 per foot. At the completion of this well (202 days drilling), approximately 1850 feet of tubing had been retired with a salvage value of 50 cents per foot, making the net cost to the well about $460. In addition, 804 collars were used (including 241 replaced at the completion of the well) at a cost of $2725 to which should be added rig time for changing 563 collars at the rig (2 minutes per collar at 61 cents per minute) or $685. If we assume that the pipe used is 50 percent depreciated which would amount to $0.755 — 0.50 × 10,319 feet) × 50 percent = $1315, this gives a total cost of $460 + $2725 + $685 + $1315 = $5185 for 202 days' operation, or $25.66 per day for depreciation and maintenance of drill tubing. As previously stated, no direct comparisons with drill pipe costs are available but comparing the foregoing to a minimum drill pipe rental figure of $0.01 per foot

TABLE 3
Recapitulation of Costs of Wells Drilled in Areas "C" and "D"

	Depth (Feet)	Hole Size (Inches)	Cost Per Foot (Dollars)	Adjusted Cost Per Foot (Dollars)	Contract or Shell	Completion Date	Tubing or Drill Pipe (Inches)
Area "C"							
Well 5	3,350	7⅞	13.07	15.24	S	12-29-46	3½ T.
Well 6	3,350	7⅞	9.03	10.28	S	1-14-47	3½ T.
Well 7	3,400	7⅞	8.39	9.83	S	1-28-47	3½ T.
Well 8	3,400	8½	10.41	11.25	C	4- 8-47	4½ D.P.
Well 9	3,500	8½	9.35	9.35	C	2- 2-48	4½ D.P.
Area "D"							
Well 10	7,006	8½	15.84	23.42	C	6-30-44	4½ D.P.
Well 11	5,000	6¾	10.61	10.61	S	6-13-47	3½ T.

This Modern Rotary Hose is



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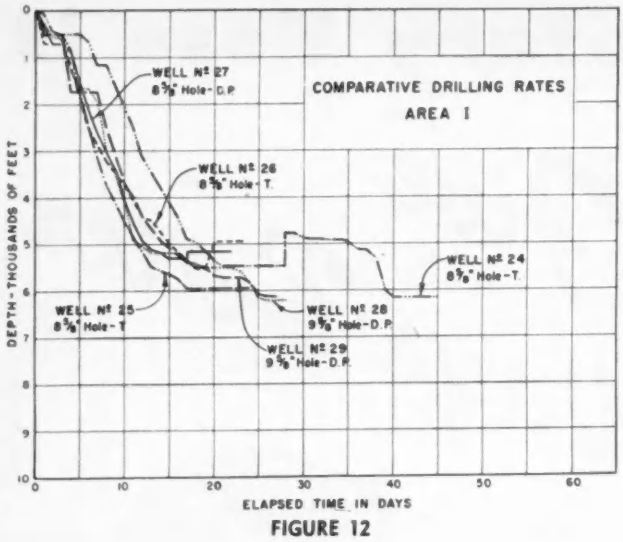

FIGURE 12

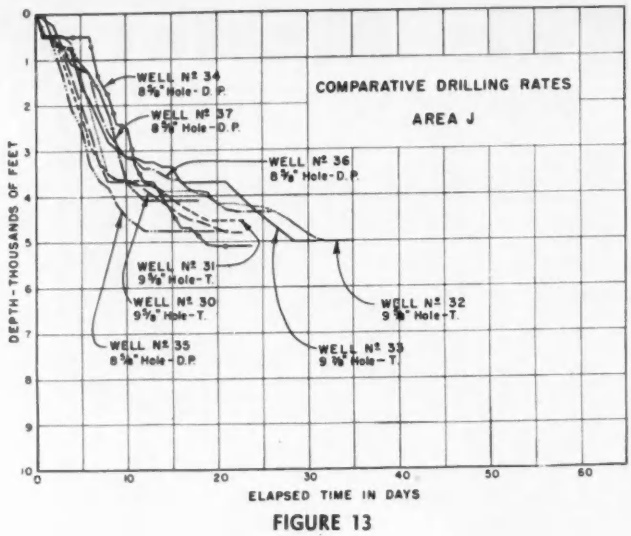

FIGURE 13

per day leaves little doubt as to the saving possible with drill tubing.

Early studies of lightweight alloy drill tubes, together with the indicated saving through the use of lightweight drilling equipment, led to the belief that exploitation wells could be drilled more economically by employing the technique of lightweight equipment handling lightweight pipe. Subsequently, 12,000 feet of 4½-inch O.D., 9.4-pound, 0.205-inch wall, 8740 steel Acme-thread upset tubing was purchased.

Since that time, 9 wells have been drilled with this 4½-inch lightweight tubing. These wells ranged in depth from 3650 to 6150 feet and the hole size included 8⅝-, 9⅝- and the one 11-inch hole. The footage drilled by these tubes to date totals about 40,000 feet, requiring 246 round trips.

Normal California techniques were employed insofar as table speed (50 to 300 revolutions per minute) and weight on bottom (4000 to 18,000 pounds) were concerned. Also, the normal functions of formation testing, plugging, whipstocking, fishing, and squeeze cementing were performed with these tubes without difficulty.

To date, 32 collars have been changed and 2 joints have been retired. The life remaining in the tubes is not known but physical inspection indicates that at present the tubes show no appreciable wear in the pipe or threads. No twist-offs have occurred, but while drilling one well the pipe became stuck owing to lost circulation and had to be shot off, leaving 4 singles, the drill collars and the bit in the hole, which were later cemented and then sidetracked.

For comparative purposes the 8 4½-inch tubing-drilled wells have been divided into groups. In the first group of 3 (Figure 12), it is possible to compare drilling progress to a depth of 5135 feet before noncomparable operations such as drill stem tests or lost circulation occurred. The tubing-drilled wells reached this depth in the average time of 18½ days exclusive of rig-up time, whereas the average time for the conventional rig was 16 days. If the first tubing-drilled hole (19 days), which experienced some mechanical trouble with the hoist, is eliminated, the average for the remaining 2 wells is 14 days; or in other words, the rate of penetration is comparable. The average daily operating cost for the tubing-drilled wells was $1000 per day and the average cost per foot was $10.65, which is comparable to $1152 per day and $12.16 per foot for the conventional rig.

The second group of 4 tubing-drilled wells (Figure 13) is comparable only to a depth of 3300 feet. The average time for the tubing-drilled wells was 8½ days whereas comparable conventionally drilled wells reached this depth in 9 days. Comparisons at greater depths in this group of wells cannot be made because of severe lost circulation encountered.

In judging these comparisons it must be remembered that all wells using 4½-inch tubing as drill pipe were drilled with a small rig having a 96-foot mast and a 270-horsepower diesel power plant, whereas all wells drilled with drill pipe employed equipment pulling full 93-foot stands and powered with a minimum of 700 horsepower.

In addition to the foregoing, we have used 2½-inch, 6.5-pound J-55 external upset tubing with Acme-type threads for completion purposes on 10 wells in the Ventura Avenue field ranging in depth from 4500 to 8400 feet. After the 7-inch casing has been cemented at the top of the pay section, the tubing is made up and from 270 to 1050 feet of new 6-, 6⅛- or 6¼-inch hole drilled. The number of round trips ranged from 4 to 11 per well and included bit changes, shoe and formation testing, plugging, sidewall sampling and liner hanging. Detailed analysis indicates that these operations are performed with tubing as rapidly as with drill pipe. To date, no indications of tubing leaks have been noticed.

In view of our experience to date, which has been highlighted in the foregoing discussion, we are convinced that in many instances drilling costs can be reduced by substituting lightweight tubing with Acme-type threads for heavier drill pipe as this permits the use of a smaller drilling rig with attendant reduction in moving and operating cost without sacrifice of drilling progress.

About the Author

W. F. Bates is a graduate of Stanford University, where he received an A. B. degree in 1934. Immediately after graduation he joined Shell Oil Company, and with that company has completed engineering assignments in Long Beach, Ventura and Bakersfield, Calif. He has had headquarters for the past 5½ years in the Los Angeles office of Shell, where his work has been connected with drilling problems. He has presented several papers before the API and other technical and petroleum associations.

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New WHIPSTOCK Technique for Hard Rock Drilling

By C. P. COLLINS
Eastman Oil Well Survey Company
Denver, Colo.

DIVERTING THE course of a bore hole such as straightening, sidetracking, controlling its direction, and other related problems have had primary consideration and study on the part of drilling engineers since the beginning of the oil industry. Necessity created and caused the development of the "wedge"—later known as the "whipstock"—which, with its modifications and combination of uses, is the tool most universally used today for the specific purpose of diverting a hole.

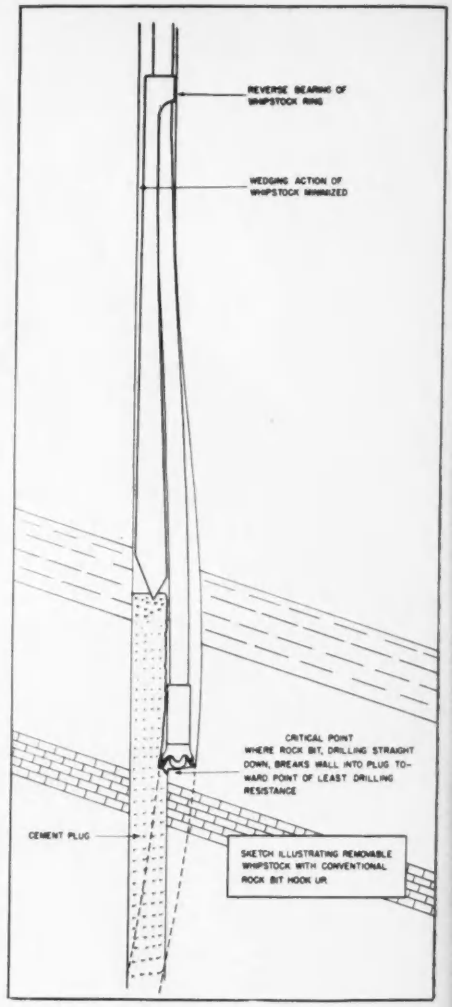
REVERSE BEARING OF WHIPSTOCK RING
WEDGING ACTION OF WHIPSTOCK MINIMIZED
CRITICAL POINT WHERE ROCK BIT, DRILLING STRAIGHT DOWN, BREAKS WALL INTO PLUG TOWARD POINT OF LEAST DRILLING RESISTANCE
CEMENT PLUG
SKETCH ILLUSTRATING REMOVABLE WHIPSTOCK WITH CONVENTIONAL ROCK BIT HOOK UP.

FIGURE 1. Illustrating tendency of rock bit to return to cement plug when attempting to sidetrack in dense formations.

LATE in 1934, hard rock drilling bits were first adapted to the removable whipstock. The retrievable whipstock was then a relatively new device and its use in conjunction with rock drilling bits was definitely an innovation.

A new horizon was opened with the use of the rock bit in combination with the retrievable whipstock, for now problems such as those encountered in the drag bit formations could be undertaken throughout the vast area where rock bits were required.

Whipstocking in hard rock presents a more difficult problem than in soft formations, particularly when the job requires a deflection from the bore hole in cement or plug-back operations. In practical experience, it is found that usually the relative hardness of formations such as sandstone, shales, and limestone, is much greater than the cement plug set in the well.

To drill the harder formations, greater weight has to be applied to the whipstock bit and the combination of hardness of formations and the weight required on the whipstock bit in order to drill the formation often causes the bit to break toward the plug after passing the bottom point of the whipstock (Figure 1).

The critical point at which the whipstock bit will break back into the cement plug is usually 6 to 8 feet below the bottom of the whipstock.

It has been this problem which has caused the setting of so many whipstocks on the majority of sidetracking jobs in the hard rock country and consequently has been the principal concern of the operator and a definite challenge to the directional drilling engineer. It was felt that excessive rig time and the number of bits consumed could be reduced substantially if some means other than the regular rock bit could be substituted in

About the Author

C. P. COLLINS, a native of Vermont, received his degree in petroleum geology from Oklahoma University at Norman, Okla. Following his graduation, he worked on geological surveys in the Orient, Venezuela, South America, and Trinidad.

He joined the staff of the Eastman Oil Well Survey Company in August, 1934, and is now vice president and manager of the Rocky Mountain-Mid-Continent division of the company, with headquarters in Denver. The hard-rock formations of the Rocky Mountain region have been of particular interest to Collins, who has given much study to the problem of the proper drilling tools for penetration of such formations.

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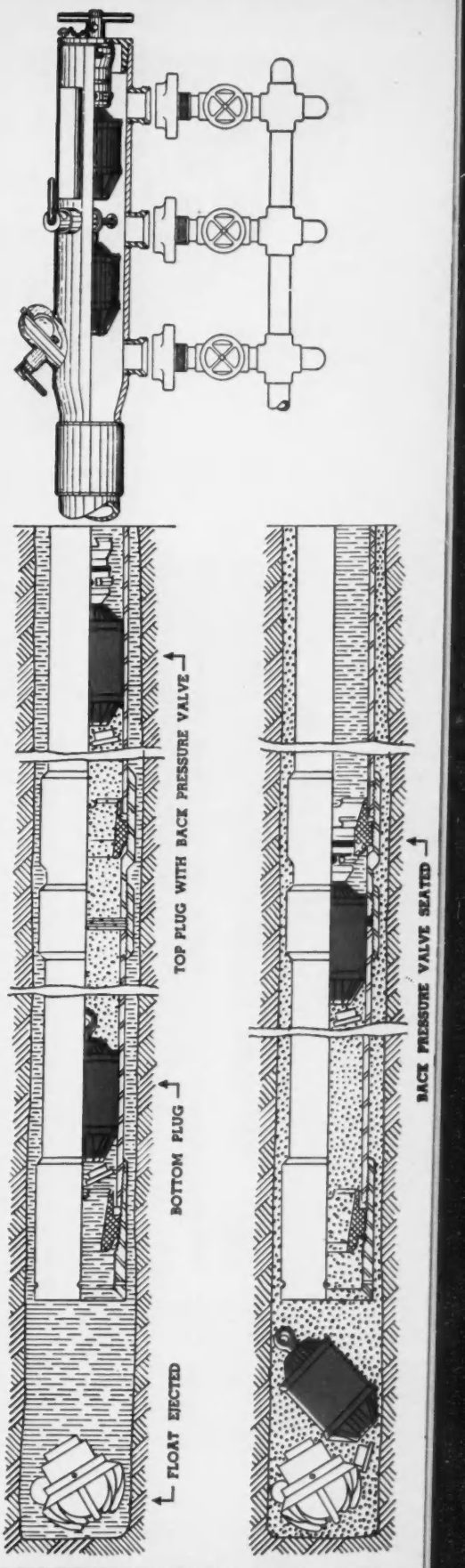

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FIGURE 2. Method of hooking up diamond core bit to standard type whipstock.

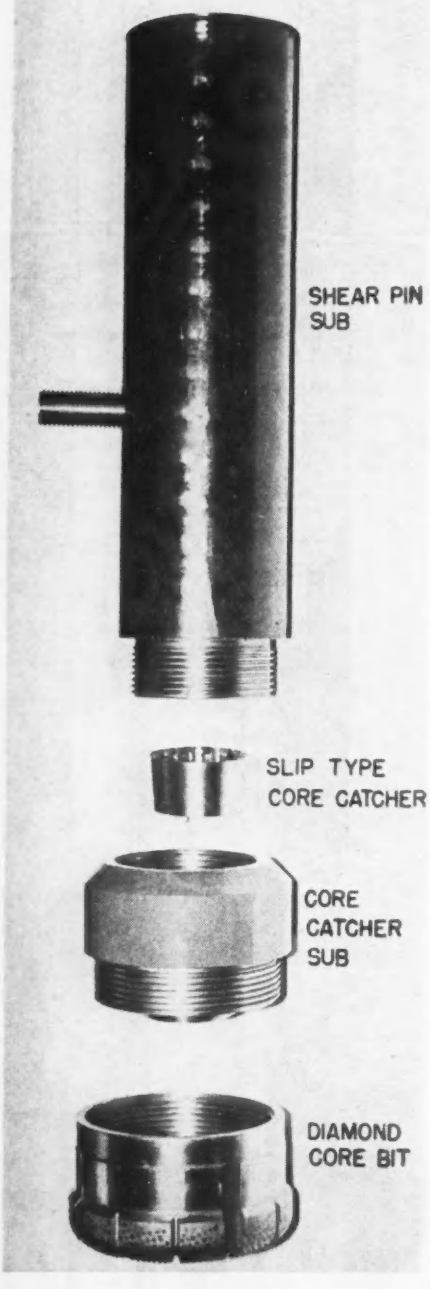

FIGURE 3. Makeup of assembly used when diamond core bit is used with retrievable whipstock, showing component parts before combining.

drilling off the whipstock.

It was a foregone conclusion that if a well could be sidetracked with one and not to exceed two whipstock settings and the consumption of not more than 4 days rig time, that expensive fishing jobs could be sharply reduced, if not entirely eliminated.

Experiments have been going on in the field over a period of years; and many bits, reamers and combinations of both used in conjunction with the whipstock have not materially bettered the proficiency of whipstock operations.

There has been one school of thought devoted entirely to a type of core bit to be used in conjunction with whipstocking; and a few early and scattered applications of this principle seemed to bear out the advisability of experimenting further along these lines.

Consequently, experimentation on coring was undertaken in earnest in the Rocky Mountain area during the past year.

The first applications were made in 6⅛-inch holes and the conventional 5½-inch removable whipstock was used. The hookup used to drill off the whipstock consisted of 4 component parts (Figure 2): (1) A sub fixed to the whipstock ring by a shear pin and made up directly to 2½-inch upset tubing; (2) a lower sub used as a bowl in which is placed a core lifter of the slip type, and (3) fixed to this assembly a 4¾-inch diamond whipstock bit designed to take a 2 7/32-inch core (Figure 3).

In practical application, drilling off the whipstock proceeds in the same manner as has been the practice with rock bits. As the core bit enters the formation or the side wall of the hole, the formation core passes through the bit and up the 2½-inch tubing, and in effect aids in holding the bit in formation until the desired footage is made below the whipstock. The bit is then pulled, lifting the core as well as the whipstock (Figure 4).

A reduced size hole results after drilling off the whipstock and reaming is required to bring the hole to the original gauge. Rather than open the hole with the conventional short stinger type bit and risk breaking down of the thin side wall, a new reaming combination was devised which would ensure the bits following the pilot hole (Figure 5).

This hole opening device consists of a core bit through which is dressed 18 to 20 feet of hydraulic tubing to act as a guide or stinger. The tubing is fixed to the bit with a shear pin at its upper end and is readily sheared when the stinger reaches the bottom of the pilot hole. To ensure its entering the pilot

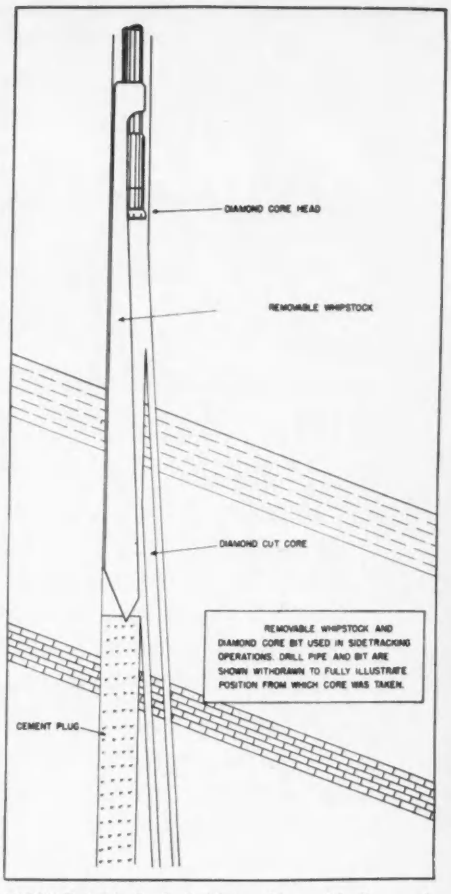
DIAMOND CORE HEAD
REMOVABLE WHIPSTOCK
DIAMOND CUT CORE
REMOVABLE WHIPSTOCK AND DIAMOND CORE BIT USED IN SIDETRACKING OPERATIONS. DRILL PIPE AND BIT ARE SHOWN WITHDRAWN TO FULLY ILLUSTRATE POSITION FROM WHICH CORE WAS TAKEN.
CEMENT PLUG

FIGURE 4. Method of sidetracking with diamond core bit, showing shape and amount of formation cored from and below whipstock.

TABLE 1
Relative Cost Data on Conventional and Coring Methods of Whipstocking

JOB I	Conventional	Core Method
Total Elapsed Time	15 Days	11 Days
Whipstocks Set	6	3
Round Trips	14	7
Bits	10 (Rock)	5 (1 Diamond) (4 Rock)
Rig Shut Down	12 Hours	0 Hours
Total Footage Drilled	124 Feet	40 Feet
Total Cost to Customer	$13,599.96	$10,961.96 (Saving 19 Percent)
Results:	Failed	Successfully Sidetracked

JOB II	Conventional	Core Method
Total Elapsed Time	27 Days	9 Days
Whipstocks Set	7	3
Round Trips	20	14
Bits	15 (Rock)	2 (Diamond)
Rig Shut Down	240 Hours	0 Hours
Total Footage Drilled	54 Feet	48 Feet
Total Cost to Customer	$22,409.12	$10,040.00 (Saving 55 Percent)
Results:	Failed	Successfully Sidetracked

JOB III	Conventional	Core Method
Total Elapsed Time	15 Days	4 Days
Whipstocks Set	9	2
Round Trips	18	4
Bits	7 (Rock)	4 (Rock)
Rig Shut Down	36 Hours	0 Hours
Total Footage Drilled	70 Feet	68 Feet
Total Cost to Customer	$14,937.00	$4,340.40 (Saving 71 Percent)
Results:	Failed	Successfully Sidetracked

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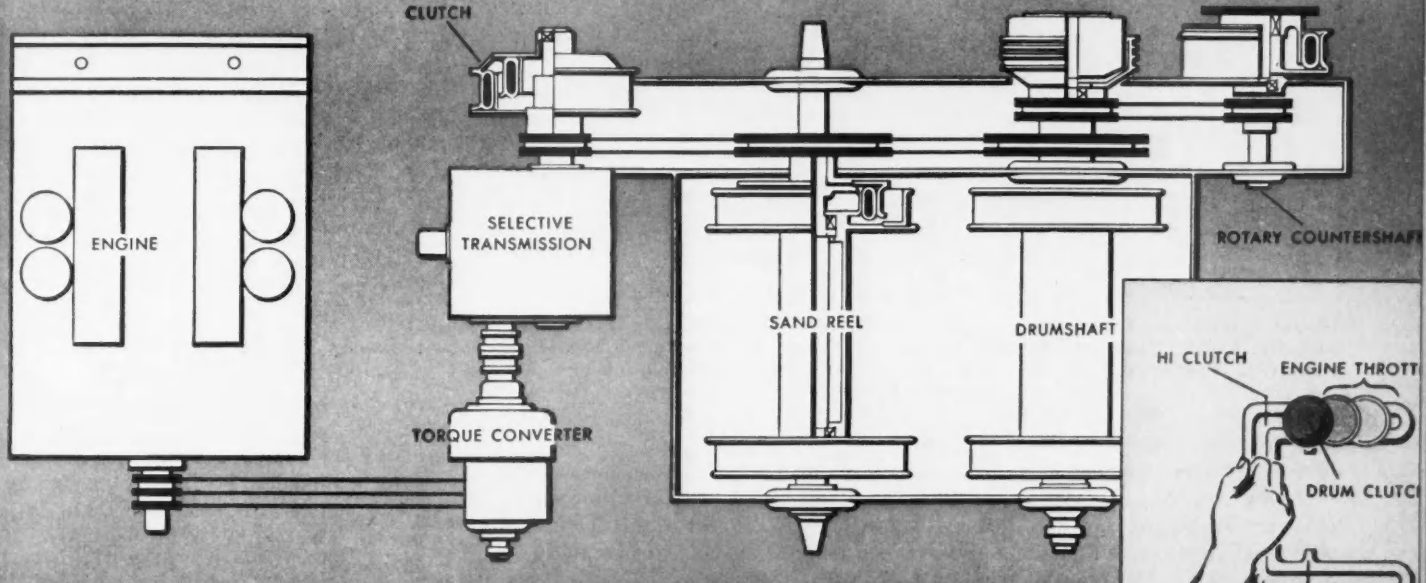

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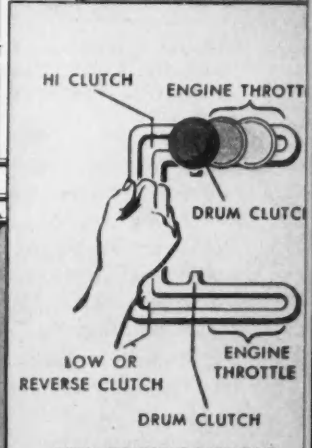

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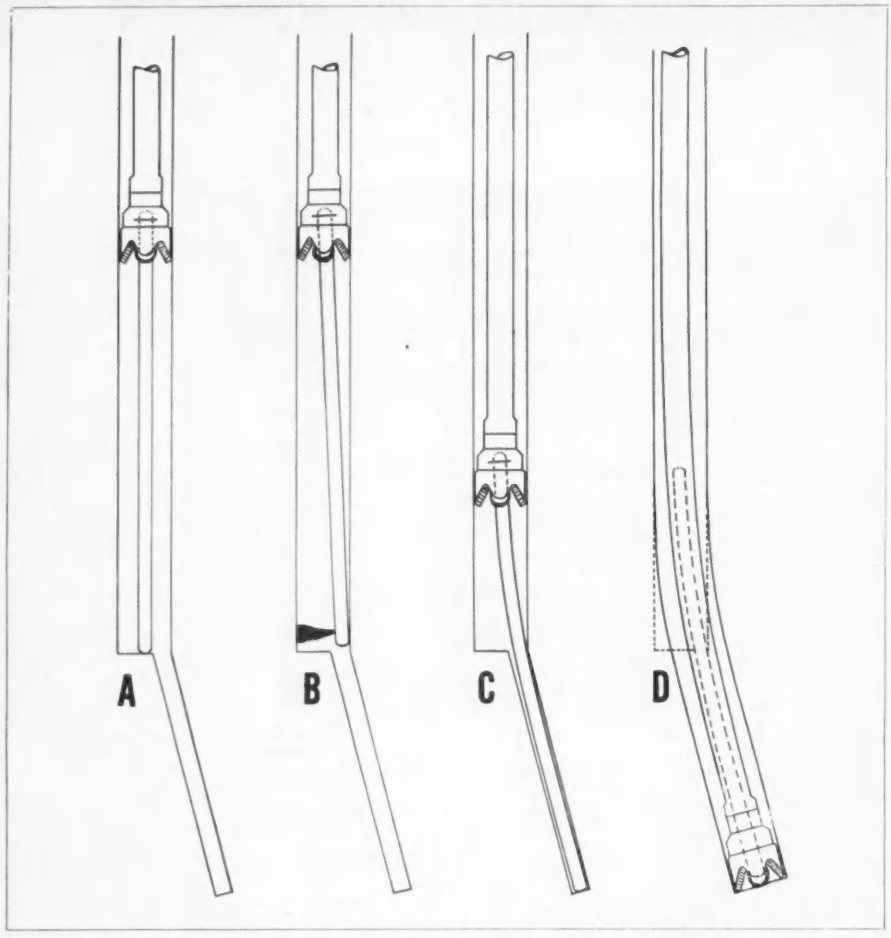

FIGURE 5. Illustrating the operation of special hard rock bit for reaming pilot hole to full gauge bore. Not drawn to scale. A—Reaming assembly on bottom. B—Locating rat hole with pump pressure. C—Pilot in rat hole before pin is sheared. D—Pilot telescoped in drill pipe. Rat hole reamed to full gauge.

hole, fluid is circulated through the side of the foot piece of the pilot extension. Pumping action holds the pilot pipe to the side of the hole so that with slow rotation of the drill pipe, the stinger extension enters the reduced pilot hole without difficulty.

Drilling proceeds with the full gauge bit rotating around the stinger which holds the bit in the sidetracked position. The stinger telescopes up the drill pipe as the hole is opened. When reaching the bottom of the pilot hole with the full gauge bit the stinger can be retrieved if desired with a wire line and a directional single shot picture taken while the bit is on bottom. Considerable rig time is saved by this procedure, providing wire line equipment is available.

Satisfactory Results

The use of core bits in conjunction with the removable whipstock has proven satisfactory as can be seen from a summary of jobs listed showing economy in time and money effected by this procedure. The first 3 jobs undertaken where core bits were used were started with conventional bits and reamers and followed conventional lines. Failing to sidetrack, the core bits and whipstocks were put into use. In each case using core bits, sidetracking was accomplished with the first tool setting, resulting in savings of 19 to 71 percent to the operator. Data on these 3 jobs appear in Table 1.

Where formations require the diamond core bit, over-all savings in rig time more than offset the diamond cost.

Furthermore, in using core bits in conjunction with the removable whipstock, no "roll-off" or turning of the whipstock facing or setting has been experienced, making it possible to eliminate error due to these forces.

Cores of the formation, which may or may not be important in an operation, are obtained simultaneously with whipstocking operations. Core orientation may also be determined from the core obtained with a satisfactory degree of accuracy.

The use of core bits with the removable whipstock is not limited to the diamond core bit or small diameter bits; conventional core bits are readily adaptable and the size range is flexible to conform to the various diameter whipstocks. In the larger size core bits, 10 to 20 feet of single type core barrel are necessary to provide for the larger core.

Running Into Crown Block

IN THE June, 1950, "Safety Hints on Drilling," put out by the American Association of Oilwell Drilling Contractors, appears the following communication from Danciger Oil & Refining Company:

In all our "Rig Up" Safety Meetings for the past 2 months, we have fully discussed the traveling block and crown situation. Manning, daylight driller on Rig 11, came up with the answer last week when he stated: "All a man has to do is to throw out the clutch and apply the brakes before the crown is reached." That is exactly what we would like for all drillers to do in every case, but there are always a few who do not carry out this plan and as a result the crown is struck by the traveling block, resulting in the loss of personnel, loss of equipment, and loss of time. Two questions were asked: (1) "What are the causes for the driller running into the crown?" and (2) "How can we as a drilling crew keep from running into the crown?"

Under these two headings we listed below the items the drillers and crews talked about most:

1. **Causes for Driller Running into Crown:** (a) negligence on driller's part, (b) lack of familiarity with equipment, (c) watching some other part or parts of machinery and not looking up, (d) operating equipment too fast, (e) failure of crew members to recognize their position to warn driller, and (f) failure of equipment.

2. **To Prevent the Traveling Block from Striking Crown:** (a) use rubber bumper. "This will not prevent block from striking crown but it will absorb some of the shock if not struck too hard"; (b) have fluid drives on power equipment. "Again this will not prevent block from striking crown but will absorb some of the shock and maybe give the driller a chance to throw out master clutch"; (c) keep safety valves on the steam rigs in good condition and making sure the cord running from valve to driller is not fouled under some object which would prevent it from being released; (d) keep your mind on the job to be done; (e) leave all worries at home — especially family worries; (f) cooperation among all men is essential; (g) there should not be any alcoholic beverages on a job. A man should not be allowed on job with odor of alcohol on breath or if he has a "hangover"; and (h) toolpushers should not allow doubling tours by roughnecks or drillers unless it is absolutely necessary.

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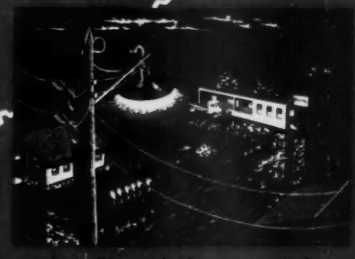

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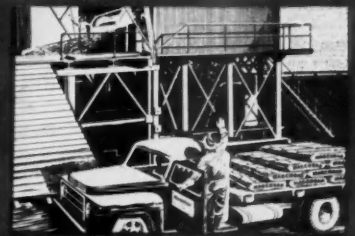

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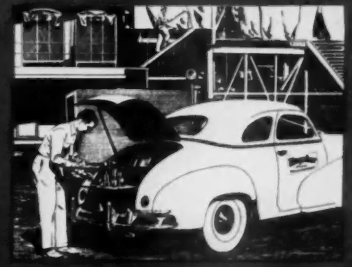

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Part 5

The Driller's Responsibility in Accident Prevention

By J. I. POWELL, Consultant

THE majority of oil well drillers are to be commended for safe handling of their numerous and exacting responsibilities.

The too infrequently reviewed angle of accident producing situations reveals, however, that the shirking of existing responsibilities on the part of some drillers leads too often to the occurrence of serious and costly operational mishaps. The results, moreover, are too often involved with the misery and suffering of those who are injured.

The damage to equipment with its attending loss of productive effort, which in some instances may even mean the loss of a hole, likewise stems from the shirking of responsibilities.

It is entirely possible that enough and the right kind of emphasis is not being applied to the oil well driller's duties. In other words, a person has to realize that he is expected to cope with certain responsibilities before he is moved to do so effectively.

A driller should come to the serious realization that he has in his care drilling equipment which, in the case of a large, modern rig, may be valued in excess of $\frac{1}{4}$ million. He should realize, too, that he has a crew depending on him to exemplify safe and efficient workmanship.

Drillers control and manipulate powerful, high speed integrated pieces of power equipment and suspended and movable weights which are capable of doing much damage and inflicting serious injury unless handled with utmost skill. Skill alone, however, is not all that is necessary in preventing equipment damage and personal injuries.

A driller must be a good observer and be able to understand the individual characteristics of his crewmen. He must know, for instance, that he and his crew must work as a team; and that they are called upon, time and time again, to go through the same identical working procedure. The objective set may be the running of the pipe into the hole and getting the bit on bottom. To reach that or any other similar objective in a safe and efficient manner the driller must know that the thinking and actions of the team are coordinated.

In this same connection, the driller must know that he should be capable of making allowances for that occasional individual who is not quite as alert in his thinking and actions as the remainder of a crew. He must know that the coordinating pattern and pace of a drilling crew must, of necessity, be in line with such individuals.

That is the way it should be because all individuals comprising a drilling crew cannot be expected to be exactly alike in every respect. On the other hand, the slower thinker often makes up for his peculiar characteristic in some other way and may even excel the more quick-minded thinkers with some other characteristic that is equally as important to the safe and efficient operation of a drilling rig.

If there is no great difference between the varying characteristics of the individual crewmen, everything possible should be done to harmonize their efforts in order to develop safe teamwork.

In order to manipulate the moving parts of a drilling rig safely, the driller must have in mind such guiding thoughts for establishing what he believes to be a safe maximum speed to fit the particular circumstances. A speed, for instance, at which a rotary is rotated, in most cases, is dependent upon the will of the driller. The rotations can be slow, moderate or fast or measured in so many revolutions per minute.

The speed at which a rotary is turned, during some phases of some particular practices, has a very definite association with accident producing circumstances. Numerous lead tong jerk and safety lines would not have been snapped or the looped attachments pulled loose, with resulting serious injuries had the rotary been operated more slowly at that particular instant.

The driller not only must assume the responsibility for seeing that the operational pace or speed of equipment is not too fast; he must also assume some responsibility for those crewmen who do not think and act in accord with related operational possibilities. A typical example of an incident wherein a crewman acted without first thinking to the extent of being governed by well known accident producing circumstances follows.

The last of the drill pipe stands that had been standing in the derrick was made-up onto the drill string. The driller was lowering the pipe string slowly into the hole. The derrickman had removed his safety belt while the stand was being made up. As the top of the pipe string and the elevators slowly passed the monkey board in their downward movement, the derrickman stepped out onto the tool joint box extending above the rim of the elevators. He grasped the

THE AUTHOR analyzes accidents which he classifies as being hoisting equipment mishaps, and points out the shortcomings in men, methods or equipment which formed the basis of the injury-producing happenings. He stresses the need for coordination throughout the crew, and emphasizes the position of leadership which the driller must assume.

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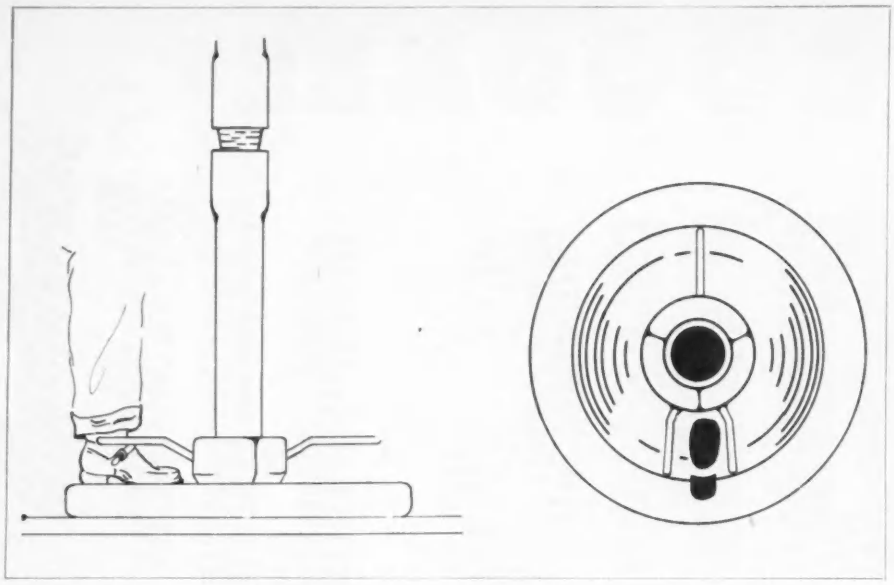


FIGURE 1. Hazardous position of floorman's foot on rotary and within sweep of slip handles which resulted in serious injury when driller started rotary to continue disengagement of threads at break-out in pipe string.

two elevator links tightly with the intention of riding safely to the derrick floor, as his work in the derrick was completed.

The driller was lowering the string slowly because he anticipated the bit's encountering a bridge as it neared the bottom of the hole. The driller had focused his sight across the top of the stationary rotary table and on the slowly downward moving pipe string, so that he could instantly detect any hesitancy in movement of pipe string which indicated that the bit was encountering a bridge in the hole.

What the driller did not know was that the derrickman had mounted the elevators as they passed the monkey board. The derrickman had no way of knowing whether the driller knew he was on the elevators at that time.

There were less than 2 singles of the pipe string extending above rotary when the bit encountered a bridge. There was an almost complete stoppage in the downward movement of pipe; the elevators, moving faster, ran down about 2 feet on the body of the pipe below the tool joint box. The bit then penetrated and suddenly dropped through the bridge. This, of course, caused the lower radial shoulder of upper box to drop down the 2 feet and hit the rim of elevators with a terrific impact.

As the top of the drill string protruded through the space between the elevator links that he occupied, the derrickman suddenly realized that he must get out of the way. He threw both arms around one of the elevator links and swung out from the space between the links. He naturally slid down the link to the point where it was attached to elevators.

The derrickman relating his experiences said he believed that had the impact of the tool joint box hitting the elevators been an ounce heavier, he would have been jarred loose from his hold. That, of course, would have meant that he would have fallen about 60 feet to the derrick floor.

The other potentially serious aspect of an incident of this kind is the fact that another driller might have been lowering the pipe at a faster clip. It is easy to understand how the combining factors of a more solid bridge and a faster lowering speed might have caused the derrickman to be caught and crushed to death between the top tool box and the bottom of the traveling hook. The alternative was being knocked completely loose from his mount and falling to the derrick floor.

This driller knew immediately that he had erred in his responsibility even though no one was injured during or as a result of the mishap.

In this drilling operation, derrickmen were being regularly permitted to ride elevators to and from their derrick work station. This was being done with the sanction of the management. What had not been worked out in detail, however, was the specification for the conditions under which derrickmen should and should not ride the elevators.

The driller assumed a degree of positiveness that all derrickmen would have better judgment than to ride downward moving elevators with the drill string attached. It, therefore, did not occur to him to look up into the derrick to be sure the derrickman was not on the elevators.

The derrickman, of course, did not consider carefully the involved circumstances and potential results of such an act. In this case he had favorable circumstances on his side. The drill string was moving slowly and the bridge encountered did not cause an abrupt stoppage of movement. A slight altering of

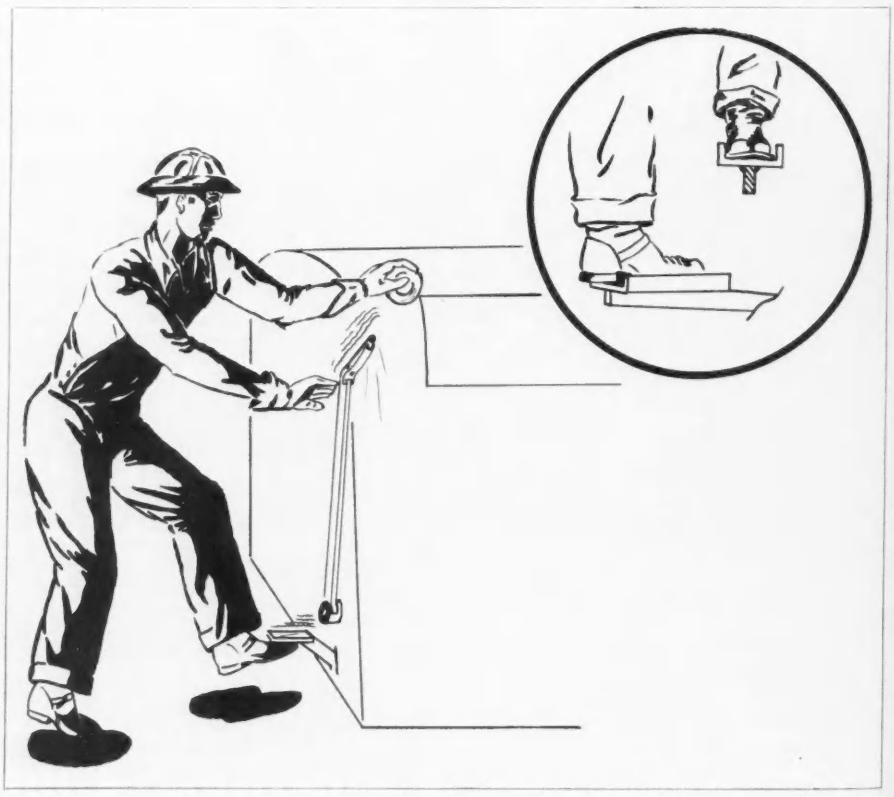
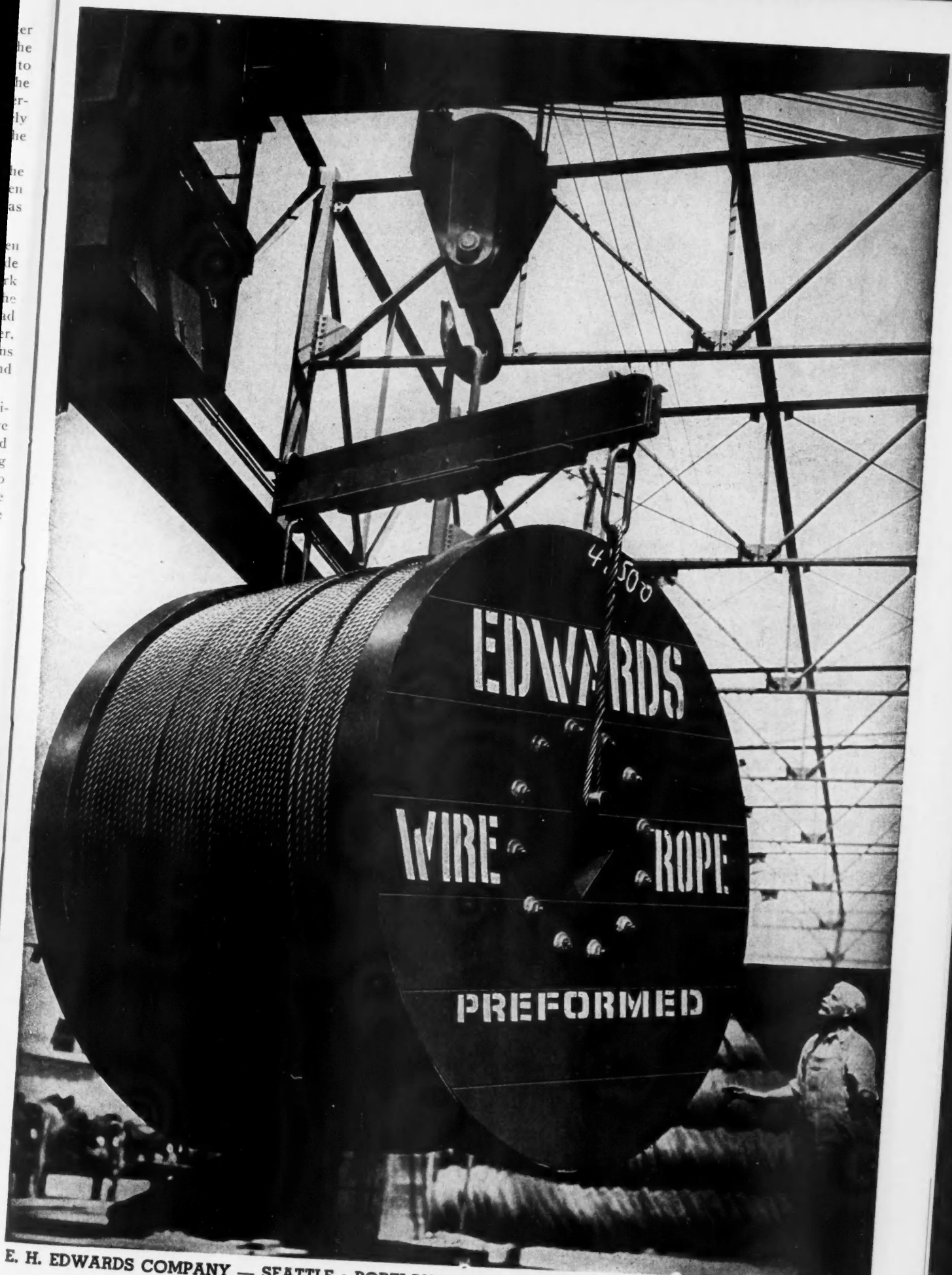


FIGURE 2. Illustrating the hazard present when drawworks clutch pedals are worn smooth or do not have side bars or other guards to retain the driller's foot in place on the pedal against the dislodging influence of vibration.



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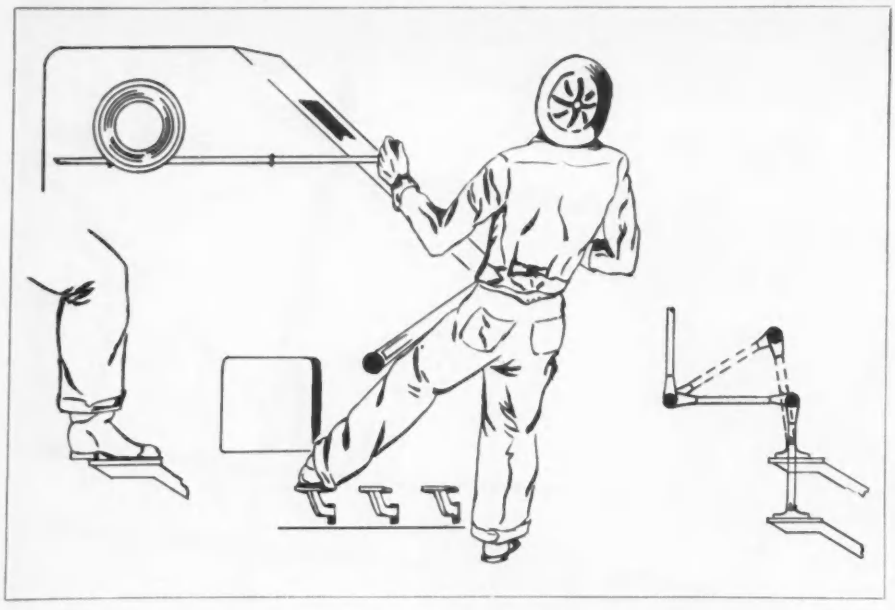

FIGURE 3. Awkward positioning of pedals on this old model drawworks requires an unnatural stance on the part of the driller, and thus exposes him to the risk of leg or groin injury. Insets show proper stance and means for operating pedal outside driller's convenient reach.

these circumstances might, on the other hand, have spelled death for a man who should have thought more before he acted.

The driller, knowing how near he came to being one of the principal contributors to the causes for a man's death, vowed to assume and act more responsibly in this connection. The driller said he would personally feel it his duty to look into the derrick each time under similar conditions to be sure the derrickman was not on the elevators. He advised other drillers to assume the same kind of responsibility.

A Rotary Mishap

A driller must feel responsible for training his crew so that each individual crewman will follow his movements as an indicator of what is about to be done. In other words, the driller must serve as a guide around which the crewmen must function as a coordinated team. The driller, of course, hasn't eyes enough to see what every man is doing or about to do, while he (the driller) for instance, has his back turned clutching the drawworks. For that reason the driller should train his crewmen to watch his movements, particularly during those phases of a practice where errors of judgment can contribute to serious operational mishaps.

To emphasize these statements with a practical example, a mishap with its resulting personal injury will be detailed.

The driller had just disengaged the rotary clutch after rotating the drill string off the pipe stand. In this incident there was not enough tension in the hook spring to pull the tool joint pin out of the box.

The lead tong man who was doping the boxes had unlatched his tongs and reached for the doping stick. Just as the rotary stopped, the lead tong man stepped onto the rotary with one foot, with the doping stick in hand, preparing to dope the box as soon as the driller hoisted the stand pin out. In stepping onto the rotary, the lead tong man set his foot down between the handles of the pipe slips.

Instead of engaging the low clutch to hoist the stand, the driller engaged the rotary clutch to finish rotating the drill string off the pipe stand. The driller thought he had disengaged the rotary clutch before the threads of the pin were completely out of the box.

The lead tong man, on the other hand, had heard the usual thumping sound of the starting threads running by each other and dropping, and he knew the pin threads were completely back-out. The driller, however, had not heard that thumping sound.

The lead tong man, without looking around to see what the driller was going to do, and casually assuming that the driller would engage the hoisting clutch, thrust his foot unknowingly between the slip handles and down upon the rotary. The driller, at the same instance, felt it necessary to give the rotary a few more turns; hence, he engaged the rotary clutch.

This man's ankle was wedged between the slip handles and as the rotary spun he was dragged around with the turning table. His leg was fractured in 2 places.

The basic cause for such an accident lies in the fact that the driller had not trained this man to watch his actions. Instead the man acted on a casual assumption.

Drillers must impress upon their crewmen that they are not perfect rig runners and that they cannot read the crewmen's minds. Crewmen must be sold the idea that they have responsibilities they themselves must respond to. But until the driller clearly instills those specific points in the minds of his men, he is not relieved of his responsibility as the leader of that team.

Accident Statistics

In the development of this paper only those accident experiences associated with the Drawworks, Hoisting and Rotary Miscellaneous Practices were considered. A total of 700 accident experiences covering the over-all operation of a drilling rig was used. From these 700 accidents, those associated with the above named practices were segregated and studied.

There were 30 accident experiences out of the 700 connected with the Drawworks Practice; 13 accident experiences associated with Rotary Miscellaneous Practices; and only 4 accidents occurred within the Hoisting Practice.

Drawworks Practice

The Drawworks Practice was set up as an operational practice category to which all accident experiences that occurred while manipulating, rigging, repairing, and the like, would be assigned. It was found from further study that the 30 Drawworks Practice accidents could be broken down into phases of the practice.

Clutching the Drawworks was a phase of the practice wherein repetitive accident occurrence was evidenced by facts. There were 7 accident experiences associated with this phase. There were 3 ankle fractures, 1 hernia and 3 severe ankle and leg lacerations.

In the mishaps that produced the ankle fractures, it was found that the clutch pedal surfaces were worn slick. There were no raised side ridges or tabs to keep a driller's foot from slipping sideways off the pedal surface. In depressing the pedal, the stationary teeth of the clutch glanced off the revolving teeth and this caused a "kick back" through the pedal. The sudden and forceful upward surge of the pedal, after the driller's foot had slipped off, caused the edges of pedal to strike his ankle with sufficient force to fracture a bone.

A considerable degree of correction can be accomplished in preventing the recurrence of this type of accident by designing the pedal surfaces so that a wet, slippery shoe sole will not slip off its surface.

It was found that the hernia resulted from a combination of factors. First, there was a kick-back through the clutch

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due to incomplete meshing of the clutch teeth. Secondly, the arrangement of the pedals in relation to the end of the drum brake lever necessitated the driller having to stretch his leg sideways to reach the pedal. Had the arrangement been so that the driller could have stood over the pedal with his knee flexed, the shock of the kick-back would have been minimized through the knee and hip joints.

This arrangement is found only on some of the very old or rebuilt drawworks. There are several known cases where the relation of the brake and pedals has been changed to afford safer manipulation of the drawworks.

The ankle and leg lacerations occurred in the same manner as the ankle fractures; in other words, by the kick-back of the clutch pedal.

Maintenance of Drawworks is a phase of the practice within which 6 accidents occurred. Two of these were associated with well known unsafe acts of attempting repairs while machinery parts were in motion. One man got his hand in the way of a fast revolving grease fitting. His hand was severely lacerated. Another man was using a pry bar near a revolving clutch. A projecting part of clutch hit the bar and knocked it into the man's face, fracturing his jaw bone.

It is safer as well as more economical to stop the movement of equipment and parts while making adjustments and repairs.

A drum shaft bearing, resting on the top of an upended block of wood, was vibrated sufficiently to cause it to fall on a man's foot. A toe bone was fractured.

A safe point to remember is that vibration around a drilling rig has caused many objects to fall from work benches and other elevated places.

Another man had his foot bones fractured during the course of removing a brake drum band. One man's foot was mashed when a sprocket puller was dropped. A burned-out and sputtering bearing contributed to one man's receiving a rather severe eye injury.

Drill Line Handling is another phase of the drawworks practice within which 6 accidents occurred. Two crewmen were using pipe wrenches to tighten the lay of the drill line in preparation for cutting it in two. The handle of one wrench slipped from one man's grasp, and it hit and fractured the jaw of the other man. Another crewman received an eye injury while cutting a drill line. A piece of steel lodged in his eye. Goggles and a corrected position in relation to a pipe wrench handle under a recoilable tension could have prevented both of these accidents.

Two crewmen were injured while spooling the drill line onto drum. One got something in his eye while hammering on the line, while the other caught his finger beneath a wrap while tension was being held on the line with a spinning rope. His finger was fractured.

Injuries occurred to 2 crewmen because they failed to anticipate and be governed by the fact that the end of a coiled drill line coming off a drum produces a terrific lashing effect. One man was hit in the mouth and he, in turn, fell backward across a piece of pipe, causing severe facial laceration and a hip injury. The other crewman also received a severe facial laceration.

The Drum Brake Lever manipulating phase of the practice accounted for 5 accidents. All of these were caused by the sudden "kick-up" of the lever at the instant the drum started rotating.

The Guard Installing and Removing phase accounted for 3 accidents. These were the result of being caught between or under the guards during the handling procedure.

The Rigging and unrigging phase of the drawworks practice contributed to 3 accidents.

All accidents that occurred within the last 3 phases could have been avoided through the development of safer working habits.

Hoisting Practice

The Hoisting Practice designation was developed as a category to which accident experiences could be assigned where the injury was sustained on the floor but occurred within the derrick structure during hoisting or lowering procedure.

A dividing line was drawn between this type of accident experience and an injury that occurred to a man up in the derrick structure. In other words, in the Hoisting Practice accidents, it was reasoned that the driller was the principal one who could have contributed to their prevention.

A driller was fatally injured when a traveling block guard's fastenings were sheared loose by shock impact and the falling guard hit the driller. The crew was starting in the hole with the first stand of drill collars. A cone of the bit momentarily hung within the blowout preventer assembly and the elevators were allowed to run down on the lift nipple. When the bit cone became dislodged and dropped, the "shock impact" caused the guard fastenings to shear. It happened that the catline was so suspended in relation to the traveling block that the guard fell on and followed the catline down until it was directly over the driller's head.

A partial shear to those guard fastenings might have occurred during the moving of that traveling block. It is believed that a safety chain, attached to

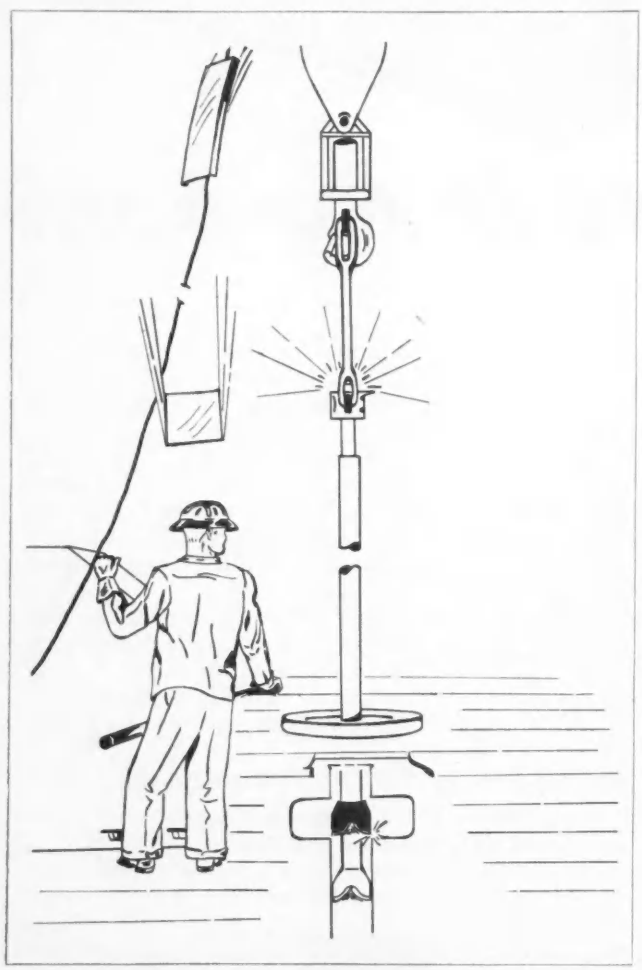
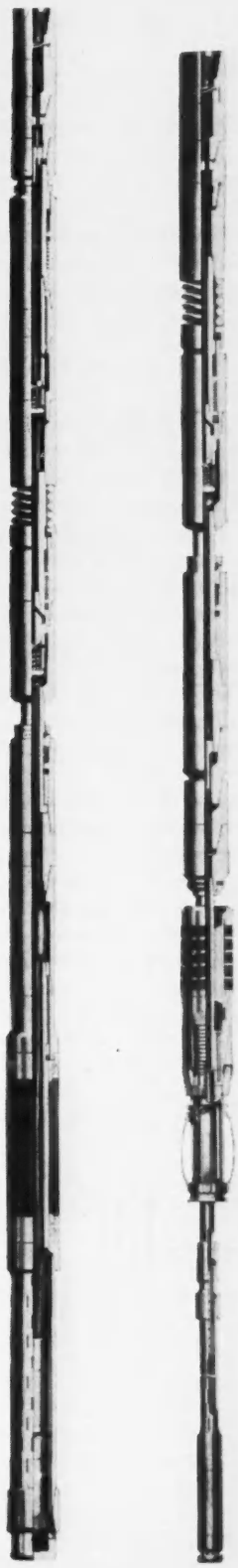


FIGURE 4. When the bit, shown in solid black in this sketch, hung up momentarily, slack was thrown on the lifting sub, and then, when the bit jarred free and fell, the resulting jar sheared the small studs holding the traveling block guards in place, allowing one to fall and fatally injure driller as it followed catline down.



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the lower edge of each guard, with the chain passing around the bottom of block, should be used on all traveling blocks.

There was another incident in which the traveling block guard was sheared loose from its fastenings as the block collided with an overhead brace in a jackknife derrick. This guard dropped to the floor at a point near the V-door. The crewman standing near that point heard the noise, looked up and saw the guard start falling. He jumped through the V-door and down the ramp. The guard, however, bounced through the V-door and hit the crewman on the back of his leg.

The protective cap over the top spring assembly on some traveling hooks is attached by small bolts or set screws. These proved insufficient to withstand the impact in one instance. The blocks were in upward motion and swinging. The cap on hook glanced on a tool joint of the racked pipe and was sheared loose. The cap fell and hit a man's arm a glancing blow.

These caps should be made more secure by the installation of a safety chain between the cap and the body of the traveling hook.

Another Hoisting Practice mishap had the potentiality of fatally injuring most of an entire drilling crew. However, only the driller was injured.

The temperature in the area where this mishap occurred had been considerably below freezing for several days. There had been a slow drizzling rain and it was hitting and freezing to every part of the drilling rig equipment. The drill line was coated with ice and the diameter of the ice coated line was 3 times the size of the line itself. The mishap occurred as the driller started picking up on about a 5000-foot string of pipe in preparation for making a rathole connection. The fast line going over the crown block sheave snapped in two.

A subsequent investigation disclosed that the grooves of the crown block sheaves were filled with hard packed ice. The lines had been running on top of this ice in the sheaves. The fast line had worked across and dropped off the edge of sheave. As the heavily loaded line hit the sheave bearing, the impact across the bearing snapped the line in two.

In consequence, the line started immediately to unstring from the crown and traveling blocks. The string of pipe, of course, fell back to the bottom of the hole. The traveling block and all the drill line fell to the drilling rig floor. A loop of the drill line hit the driller and fractured his leg. The crew had not yet come onto the derrick floor—a fortunate circumstance, because a fast escape over an ice coated floor would have been next to impossible.

Most of the new, modern crown blocks are designed so that the drill line could not work off the sheave's edge even though the groove was filled with hard packed ice. Some of the old crown blocks, however, do permit such a happening.

Where icing conditions are bad during winter months, and where crown blocks are in use which would permit such a mishap, it is strongly recommended that sheave groove scrapers be installed.

Such scrapers can be made to be attached to the side members of the crown block and the point of the scraper so positioned that it will be at the extreme lower arc of the sheave. The scraper point does not have to touch the sheave but merely extend sufficiently inside the sheave groove to keep enough ice scraped out for a track for the drill line.

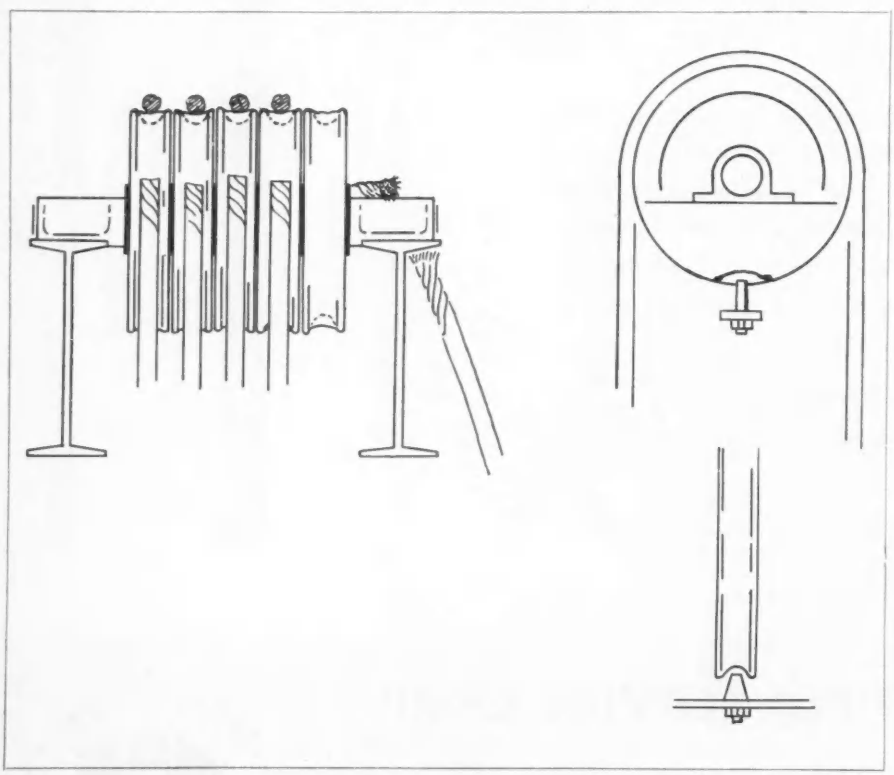

FIGURE 5. Diagrammatic sketch of simplified crown block, showing how ice packed within the sheave grooves and forced the fast line to ride over the rim and strike against the sharp edge of the block support, snapping the line and dropping block, hook and rapidly unreeving line on the floor below.

Rotary Miscellaneous Practices

A "Rotary Miscellaneous Practice" category was needed to which to assign accident experiences that showed little trend toward repetition. In other words, the accident experiences grouped hereunder are those that occurred in connection with or about the rotary and for which no other category had been set up.

A tubular legged steel rotary platform collapsed causing a crewman to fall and injured his back.

A 60-inch pipe wrench was being used in connection with rope pull line on cathead when the wrench jaw fractured, causing the wrench handle to hit a man in the mouth.

Two men were injured when the hook on catline, used in rigging a test tool, pulled loose and hit them in the face.

Injuries were sustained by 2 men while reaching down inside the rotary bowl after drill pipe stripper rubber. During their act of reaching, a swinging pipe collided with and injured them.

One man dropped a pry bar being used on rotary drive bushing on his foot; another dropped a float collar on his foot. In both instances, toes were fractured. Safety-toed shoes will assist greatly in eliminating this type of accident.

One man was struck on the side of his head when he was using a pry bar to get rotary drive bushing to seat in the master rotary bushing. The weight of bushing dropped on the pry-end of the bar in such a manner that the handling-end of the bar was jerked from the hand of the crewman.

Two crewmen were injured as a result of their being atop the stationary rotary at the instant revolving started. One of these accidents has been detailed in the forepart of this article. The other man was injured when the rotary clutch was engaged by vibration. One of the employes on rotary had his feet thrown from under him and the position in which he fell allowed the ends of whirling slip handles to strike him in the back.

The prevention of accidents is nothing more than the end result of good leadership and appropriate training in doing the job right.

How to do it!

DRILLING HINTS

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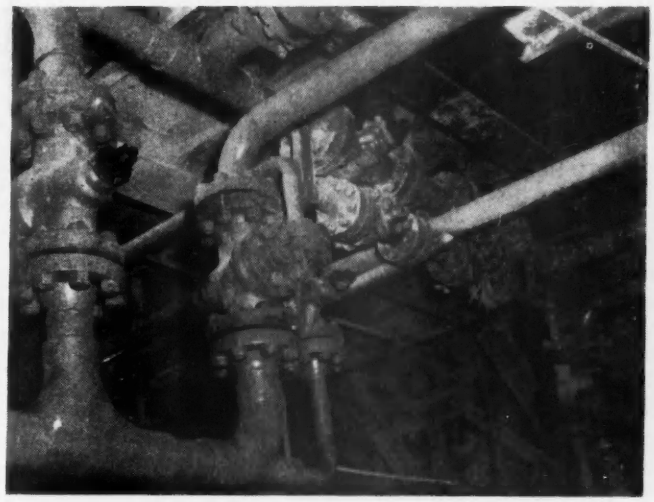
HOW TO—Improve Mud System Piping Setup



The compactness with which drilling barges and offshore drilling structures are arranged makes it necessary to utilize all available space for equipment and connecting piping. On land rigs, it is permissible to let the lines sprawl over the ground where they can easily be made up and traced. However, on offshore structures space must be utilized more efficiently.

Simplification and saving of space result from mounting most of the mud system piping overhead on an offshore drilling structure. The piping shown serves two power-driven mud pumps. The system is equipped with valves so that either or both pumps can be used for compounding in series or in parallel with a third pump. Such flexibility necessitates additional valves and connections not ordinarily required by other hookups.

In order to save space and to make it relatively easy to trace out flow lines, as much piping as possible is attached to the superstructure of the pipe racks. Angle iron brackets, U-bolts and other means of supporting the valves and piping to the framework of the superstructure are used. Where valves were frequently opened or closed, a drop nipple is added to put valve handle and valve within easy reach of the operator.

Suction lines from mud tanks are connected to the pumps at deck level, but lines leading to the standpipe, taps for feeding pit jetting guns, etc., are placed overhead, thereby providing a clean floor and making it an easy matter to check and trace all lines.

HOW TO—Utilize Single-Acting Gas Engine

Occasions may arise when a good single-cylinder gas engine of the horizontal type would be useful in powering an auxiliary mud pump. In the case illustrated, a single-acting gas engine was utilized to power one auxiliary mud pump since the engine was available and in good working condition.

Because of its weight, the horizontal gas engine was mounted on a separate skid that butted up against the power end of a power mud pump. The heavy flywheel of the engine was left intact and helped smooth out what otherwise would have been extreme pulsations on the discharge end.

The engine was connected to the power end of the pump through a heavy rotary chain drive, utilizing conventional API chain sprockets. The power take-off from the engine was through a regular disc-clutch that made it possible to disengage the pump from the engine when idling the engine.

The chain and sprockets were completely enclosed in a sheet metal guard that provided an oil bath for the chain. The metal plate extended completely around the moving parts and was made oil tight. It was flanged in the middle at the junction between the engine and the pump skids so that when the unit was broken into 2 parts, the chain guard could be broken down and each piece moved with its connecting sprocket.

While cumbersome to move, this set-up has made possible the utilization of old-type single-cylinder engines.

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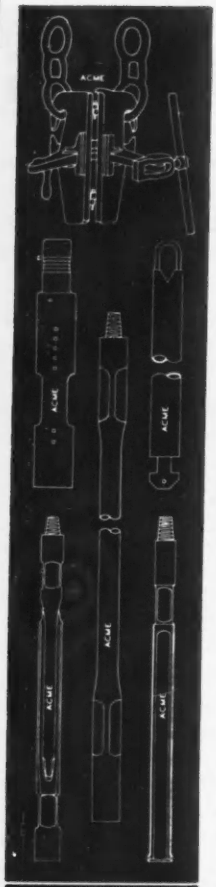

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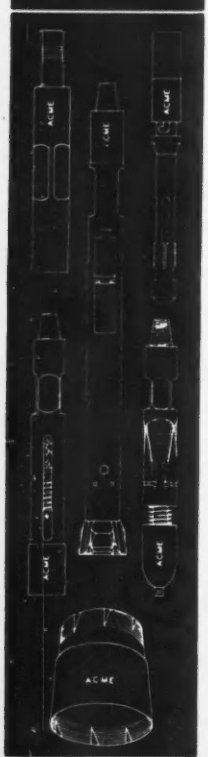

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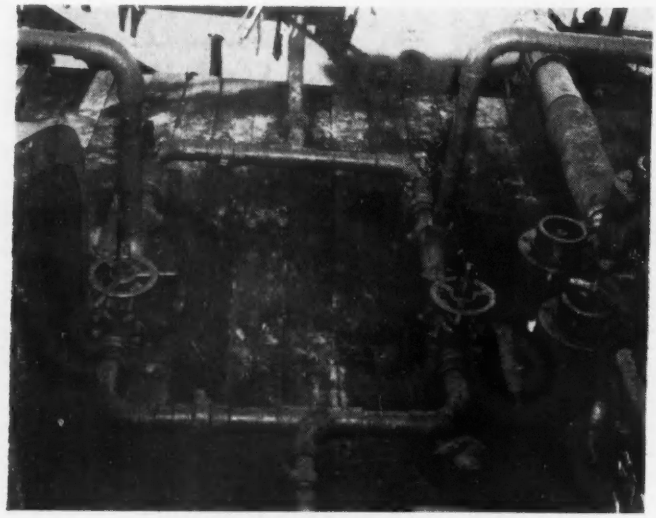
HOW TO—Parallel Pump Discharge



It is occasionally desirable to test a slush pump in actual drilling operations to determine its efficiency and compare its performance with other pumps of similar type. In placing a slush pump on test, there are periods during which the pump must be inspected and lubricated, and even changes in some parts made. Under such conditions, the connecting piping must be flexible so that a standby or a regular pump can be placed in operation when the test pump is removed from service.

A temporary, yet efficient, hookup is illustrated whereby the pump on test at right can be placed in or taken out of service as desired without interrupting drilling operations. The discharge lines of each pump (the test pump at right, and the standby pump at left) are connected to a rectangular framework of 3-inch heavy-duty pipe and fittings. The discharge lines connect to the frame near the center of each long side, permitting a mud valve to be installed on either side of the discharge.

The line leading to the background supplies mud for the jetting guns and to the mixing hopper, while the mud line leading out of the photo in the foreground is connected to the standpipe on the derrick floor. Two men standing inside the rectangular framework of piping can quickly change pumps on the standpipe with little lag in changeover. While the standby pump is idling, it can jet mud into the pits through the rear valve on the framework while the front valve is closed. By reversing the 4 valves in the system, the standby pump may be placed on the standpipe and the test pump taken out. Both pumps can be paralleled into the standpipe, if necessary.

HOW TO—Fabricate Chemical Tank

A simple, rugged unit for adding chemicals to drilling mud may be fabricated from scraps of surface casing usually found around the yard. A 2½ x 1 foot window is cut in the top of a joint of pipe and 2 8-foot pieces mounted above as shown. The 8-foot pieces are used for chemical mixing and storage and are blanked off on each end with a connection down through the window of the long piece. A short nipple of the same size pipe is placed in the top of each so that bulk chemicals can be put in.

Water and steam lines are then run to a convenient spot in the mud discharge line from the well, and the en-

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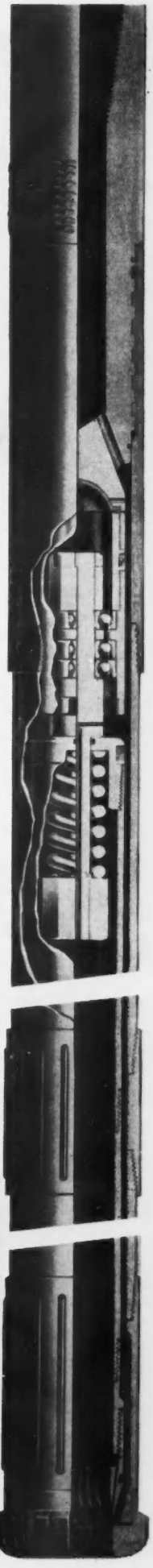

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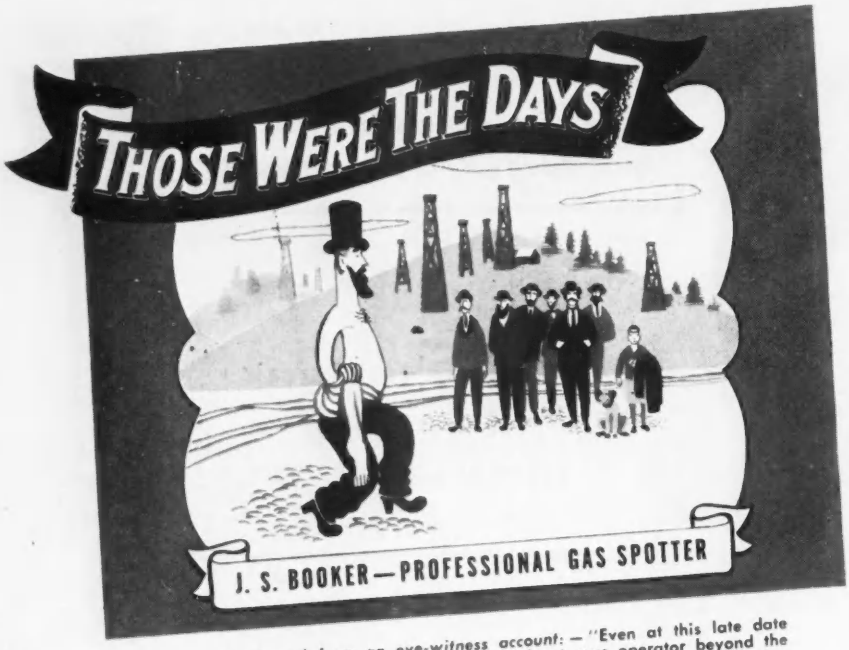

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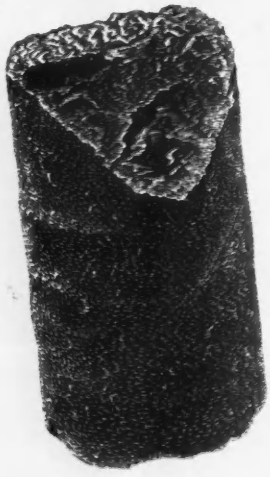

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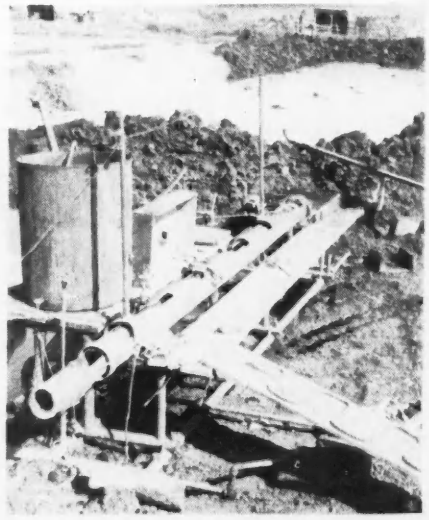
tire unit set into the line and connected up with dresser sleeves. The water and steam lines are valved and connected to each of the tanks so that steam or water may be turned in to either tank as shown. In operation, the chemicals are added through the large opening at the top, the required amount of water turned in and steam is used to heat and agitate the mixture.

HOW TO—
Make Telescoping Mud Return Line

A unitized mud return line built integrally with the mud treating equipment may be made in one piece for easy moving and rigging up.

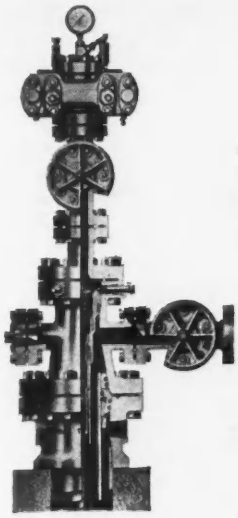
As shown, a joint of 12-inch pipe is mounted on the skids which hold the mud treating and testing equipment. Pieces of the top of the mud line are cut out to provide easy inspection and cleaning.

A joint of 10-inch and a joint of 8-inch pipe are then fabricated. The 8-inch joint is slipped into the 10-inch and both joints are placed inside the 12-inch. A 6-inch connection is welded to the



inlet end of the 8-inch for easy nippling into the top of the surface pipe.

The entire unit is moved in one load and when rigging up, the nipple from the cellar is turned in the direction of the return line unit. It is necessary only to tie a winch line to the 8-inch joint and untelescope the mud line and connect to the surface casing. Stops are provided on the ends of the joints to keep them from pulling out. A board walk was made on the same skid frame with the telescoping mud return line so that the entire assembly could be moved as a unit, without dismantling.



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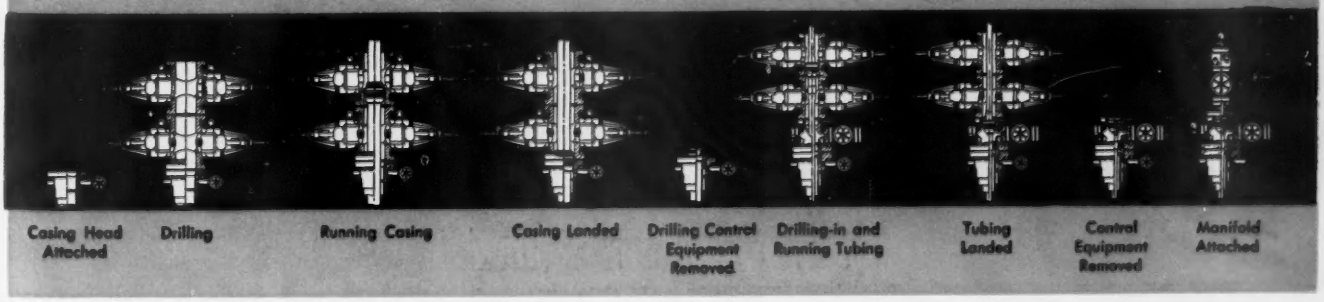

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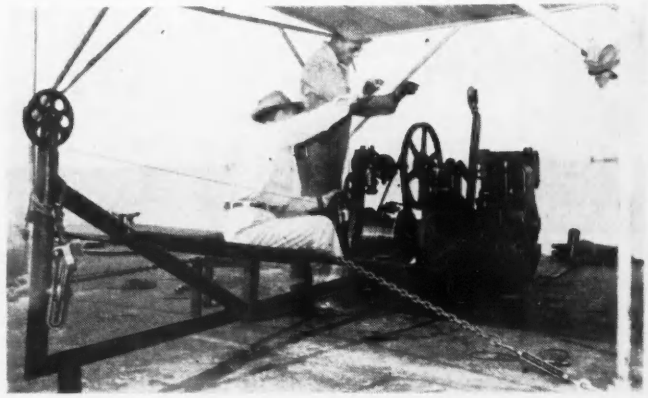
HOW TO—Rig Up Paraffin Scraper



Where paraffin must be scraped from wells, and an up-and-down action is desirable, a spudder beam may be rigged up on the pulling unit, as shown.

Where the shaft for the winch drum connects, a V-belt sheave is placed on the other side and the speed reduced to approximately 30 revolutions per minute. A slotted bar is then hinged to the bed of the unit and a pulley wheelp laced on top. The slot is turned down smooth and the crank pin fitted inside. Whenever the winch is stopped at the proper place for spudding, the clutch on the beam is thrown in and the beam moves back and forth. The wire line is threaded from the winch through a sheave welded to the end of a boom and back through the sheave on the moving beam, then to the top of the lubricator on the well head. Movement of the beam in a lateral motion then causes the scraper to move up and down in a spudding action.

HOW TO—Control Suction Height

A simple but helpful idea may be used to control the elevation of the suction of the mud pumps. It consists primarily of an A-frame resting on two pieces of pipe that span the mud sump.

The A-frame is made of 4-inch pipe and both ends are secured firmly together by pieces of 2-inch pipe welded around three sides of the frame near its lower end. The side near the pump is left open to allow the suction line to be lowered or raised. Terminating at the apex of the A-frame is a short nipple of 4-inch pipe with a hole drilled in the top side. These nipples, one on either side, form bearings for a cross piece of 3-inch pipe fitted inside the nipples. To the near end of this cross piece is welded a short nipple of 2-inch pipe into which a crowbar may be inserted as a lever in rotating the 3-inch cross member.

The 3-inch cross piece is perforated at intervals around the circumference at the near end. These holes are of the same size as the hole in the top of the bearing nipple. When a hole in the cross piece is in line with the hole in the bearing nipple, a bolt may be inserted in them to lock the cross member and thus prevent it from rotating.

The suction line is supported by discarded cat line securely tied to the suction on one end. The other end is wrapped around the cross member of the A-frame. By rotating the cross member the suction may be lowered or raised, and locked in the desired position. Curved footing pieces welded to the bottom of each leg held the A-frame in place on the spanning pieces of pipe. The unit is light and easily moved.

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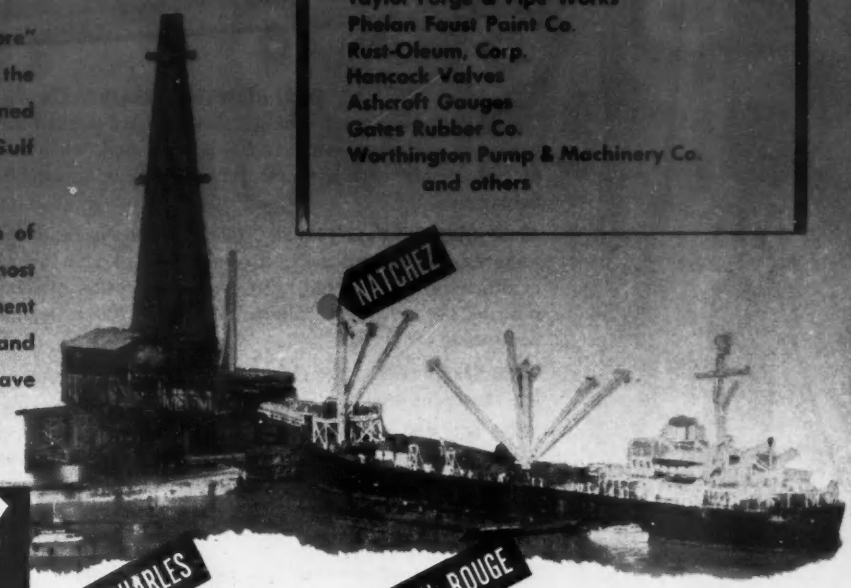

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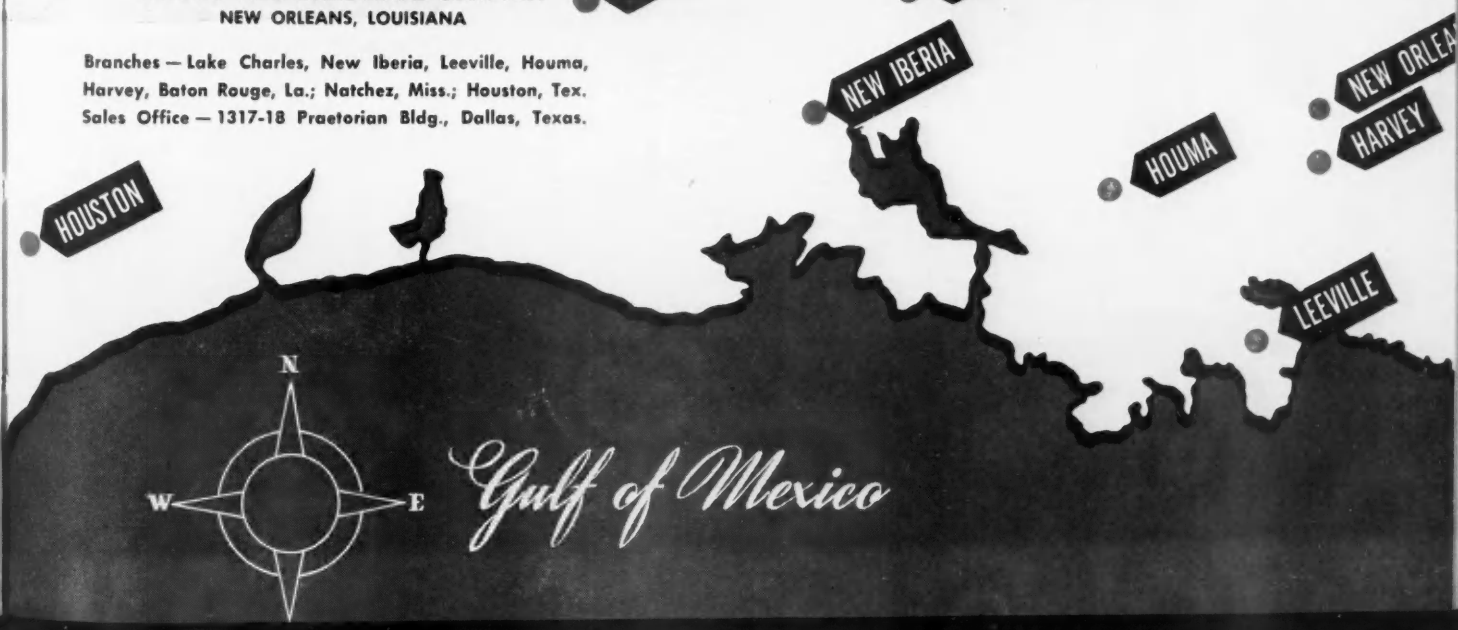
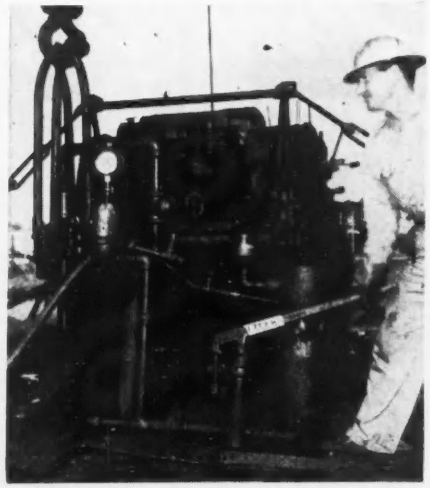


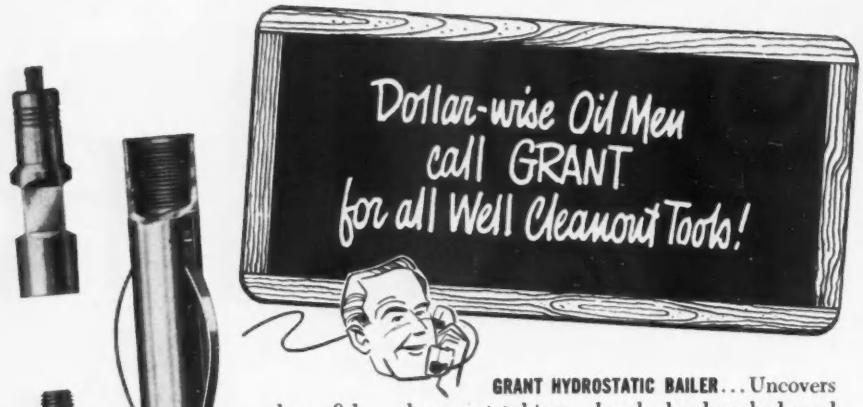
HOW TO—Find Leak in Tubing String

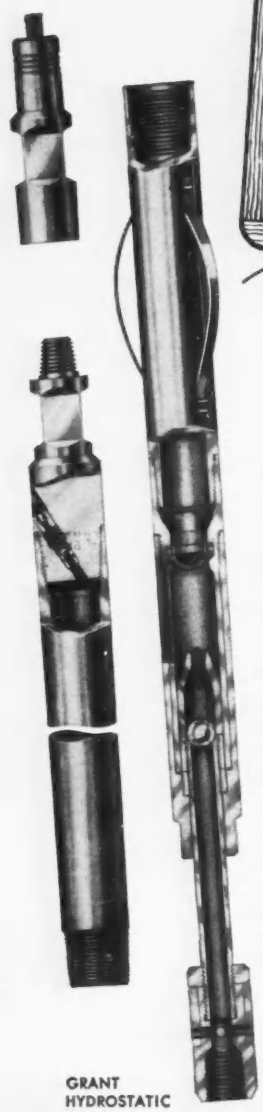
When a leak develops in the tubing, it is necessary to pull the rods, and the leak is usually stopped up with paraffin so that the tubing will hold a water level when filled.

A hydraulic pump used to test valves and equipment in the shop may be brought out and without changing any connections, used to unplug the leak in the tubing. A connection is made to the tubing full of water where the valve or other equipment to be tested is usually hooked on.

The chamber on the suction of the pump is then filled with water and the pump operated by one of the men. A few strokes place several hundred pounds pressure on the tubing string, thus opening up any holes or weak places that will allow the water to run out. As soon as the pressure breaks down, more tubing is pulled until the leak or leaks are found.







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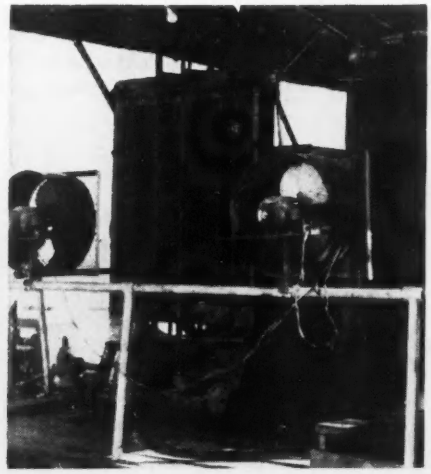
HOW TO—

Provide Additional Cooling for Engine

When engines are running hard day and night, it is sometimes difficult to keep them at the desired temperature when making a round trip in midday. In the open plains of West Texas where the temperature occasionally reaches 100° F. in the shade, large gas and diesel engines sometimes exceed the boiling range. To provide an additional means of cooling that may be easily placed in or out of use, depending upon the season, one drilling contractor uses 2 outside fans as shown.

Purpose of the fans is to force more air through the radiator than is normally drawn in by the engine cooling



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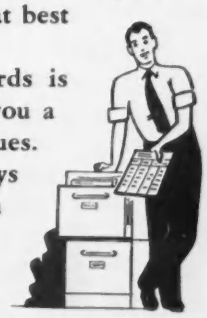

The keeping of such records is good, sound practice. Gives you a chance to compare rope values. That we like—for we're always ready to stack the Bethlehem product against all comers. You'll be, too—when you use this rope consistently.

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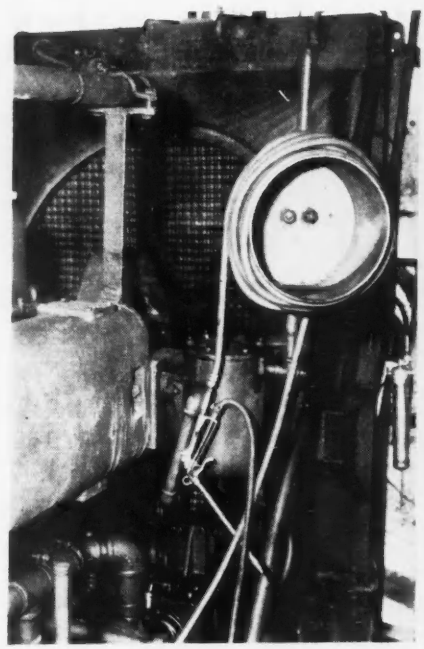
fan. These 2 fans are mounted as illustrated on the pipe handrailing surrounding the engine platform. The driving motor was a ¼ horsepower direct current motor supported on a square sheet metal plate which was mounted on a short piece of 2-inch pipe bolted to the handrailing.

The fan blades had been fabricated in a machine shop and riveted to a hub bolted to the motor shaft. A cowling of heavy-gauge tin was mounted around the fan to add to its efficiency and to protect the crew. With both fans operating, air was blown at higher velocities into the radiator shell. The engine cooling fan running just behind the radiator picked up this fast-moving air and increased the velocity. The cooling system is similar to compounding two pumps to obtain higher pressures. Here, however, air velocities force a greater volume of air through the radiator and thereby provide additional cooling.

HOW TO—
Simplify Engine Lubricating Job

The best insurance for proper lubrication of the drilling rig, and particularly the engines, lies in providing the best and simplest means to do the job. Greasing the vital points of a heavy-duty engine was made an easy chore by the installation of pressurized greasing equipment similar to that found in service stations. Grease guns such as the one illustrated were placed at strategic points on the rig and equipped with adequate hose to reach all fittings that required periodical greasing.

To store the hose out of the way between the 2 engines so it will not form



a tripping hazard, a 5-gallon grease container is used as a drum on which to wind the hose. The drum is mounted on a 1-inch piece of pipe that extends vertically from the engine to form a breather line. A U-bolt placed around the pipe and inserted through 2 holes drilled in the drum secures it to the vertical breather pipe. The grease gun is conventional, with a greasing tip which can be interchanged to fit most types of grease fittings.

The rig is normally greased at the beginning of each tour if the operation in progress permits. However, with this easily accessible grease gun, it is a matter of only a few minutes to grease all points within reach of the gun. After each job, the hose is quickly coiled on the drum and the passage between engines cleared of a possible obstacle.

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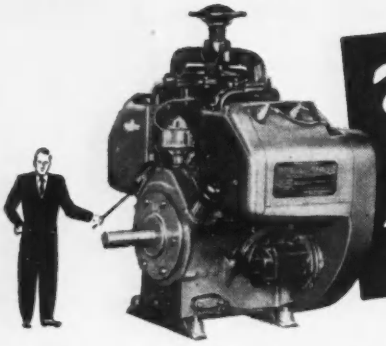

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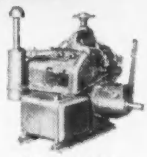
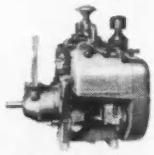


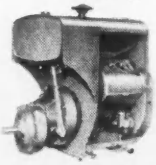
15 to 21.5 hp.

V VF-4



17.5 to 25 hp.

V VP-4



26.8 to 31 hp.

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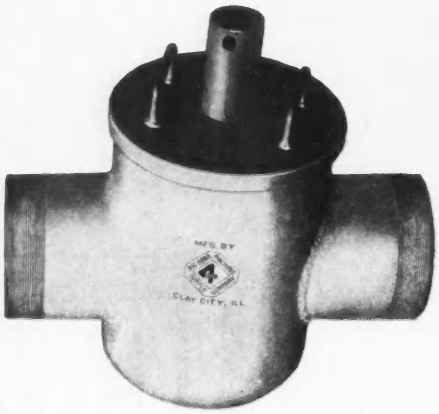

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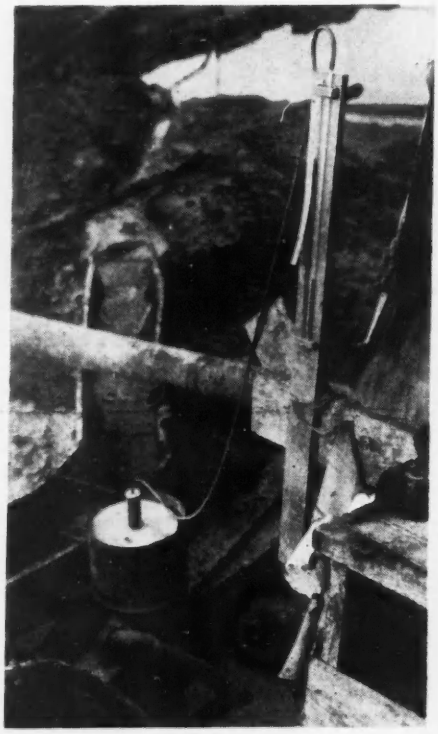
Export Office: 233 Broadway, New York 7, New York

HOW TO—

Construct Mud Weighing Device

A simple mud weighing device which will give the driller the mud weight at all times may be rigged up as shown. A grease can is cut off near the top and a container made to fit inside is inserted upside down. A neck and cork are placed in the center of the inverted container and a hose is connected to the manometer.

A connection is made near the bottom of the mud return line and a hose is connected to the bottom of the grease can. Near the top, an overflow runway is



made so that the mud will discharge into a ditch leading to the reserve pit.

In operation, the valve on the mud return line is cracked and the mud made to flow through the grease can out the runway on top. The heavier the mud is, the more it rises in the inside container and the more pressure is shown on the manometer. When the mud becomes thin and gas-cut, it stays near the bottom and only a small reading shows on the manometer.

At the beginning of each tour, the entire unit must be turned over and washed out completely as heavy mud will tend to settle in the bottom and give a false reading. However, it would take several tours for it to become very inaccurate.

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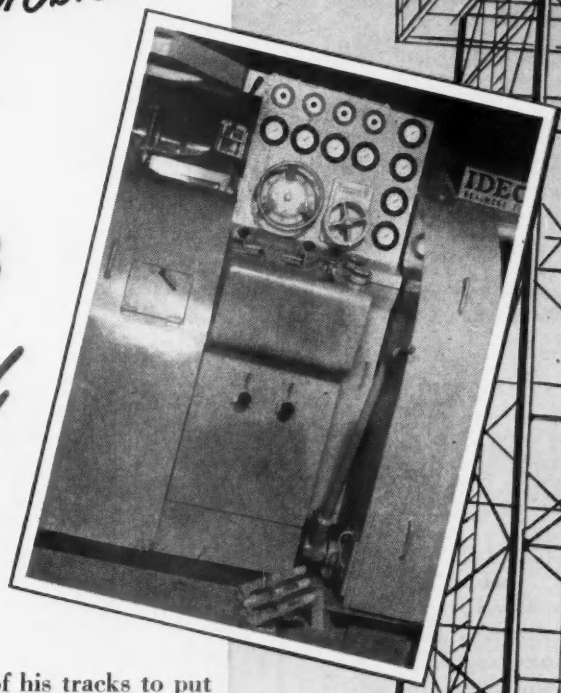

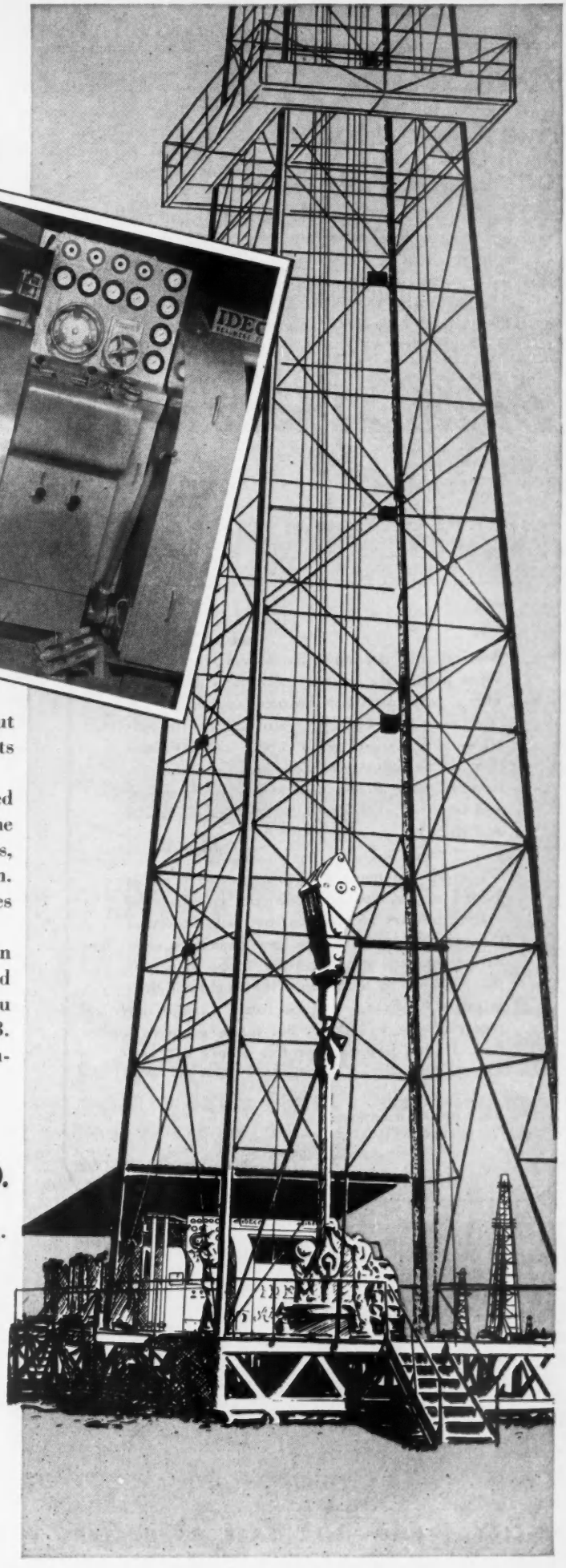

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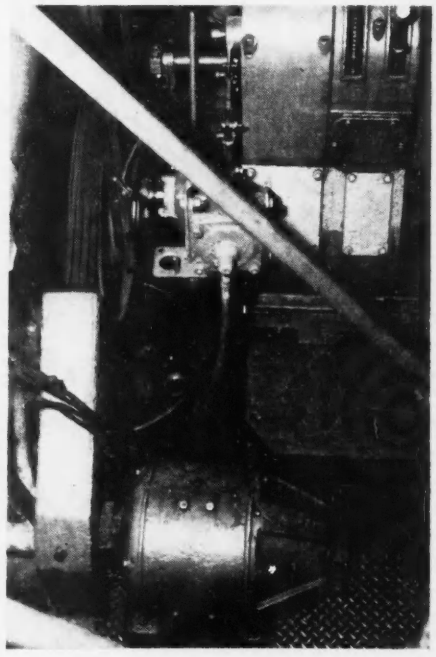
HOW TO—
Drive Generator From Crankshaft

An additional source of direct current for auxiliary uses around the drilling rig can be easily supplied at little extra expense. A large saving results from driving the 1½ kilowatt generator by a V-belt pulley attached to the crankshaft of one of the gas engines which drive the drawworks and rotary.

In the installation shown, the generator has been mounted on the metal plate flooring surrounding the drawworks engines. It is equipped with a 4-belt pulley. The crankshaft of the engine was already equipped with a V-belt pulley to power the engine cooling fan. However, a 4-groove pulley was used of the proper diameter to give the right speed on the generator when the engine



operates at approximately 600 revolutions per minute. Holes were drilled in both the large pulley and the smaller one already mounted on the crankshaft. The larger pulley was then bolted by 4 machine bolts to the smaller one. A belt guard was installed over the V-belts where the generator extended out in the passage between the 2 engines.

HOW TO—
Facilitate Running Casing in Deep Well

One of the most arduous jobs of any drilling crew is that of running casing in a deep hole. Possibly the greatest work load falls upon the derrickman who must stab each joint of pipe into the string as it goes into the hole. To do so, he must juggle the upper end of the joint to be added so that the threads are square before screwing up. In mov-

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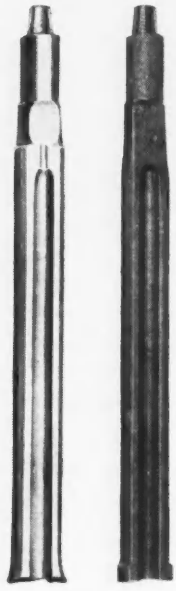

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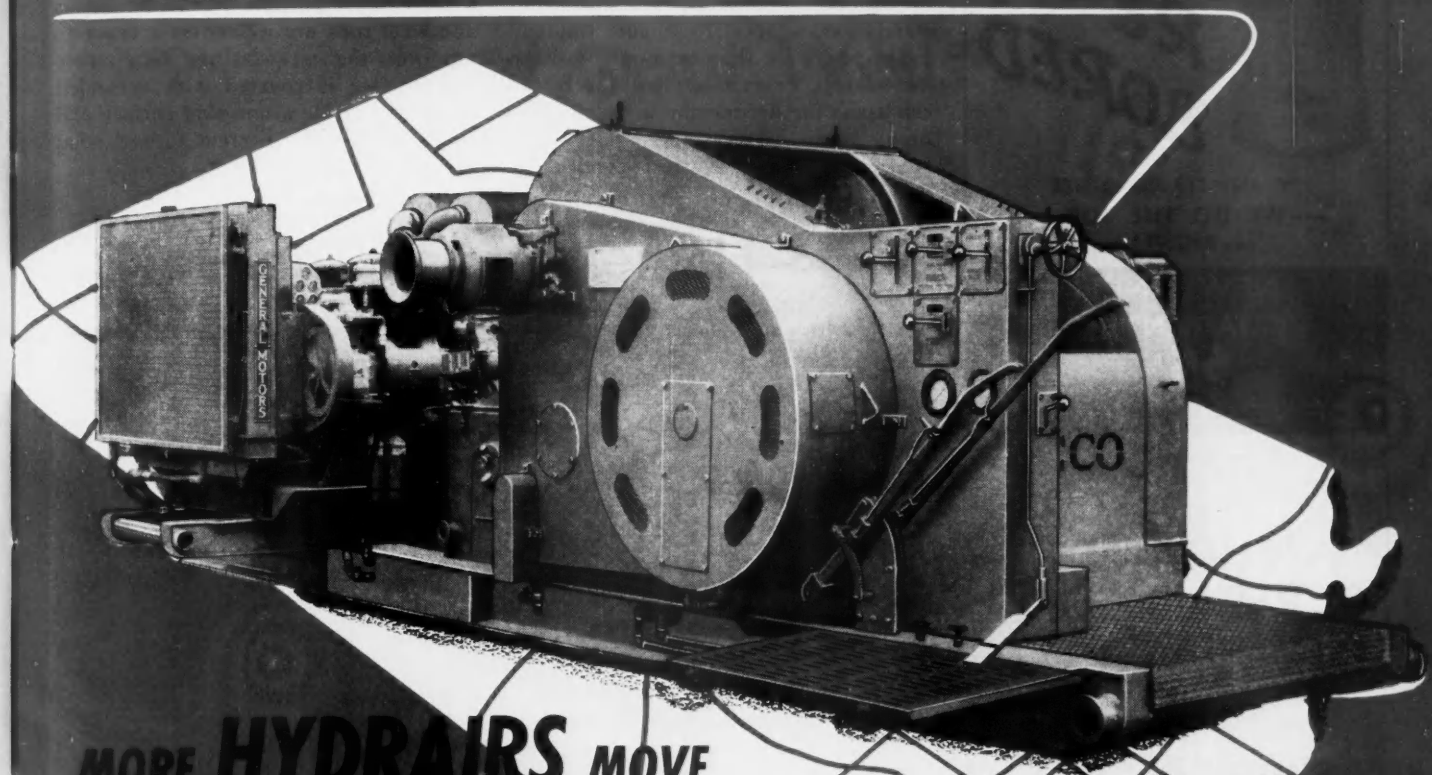

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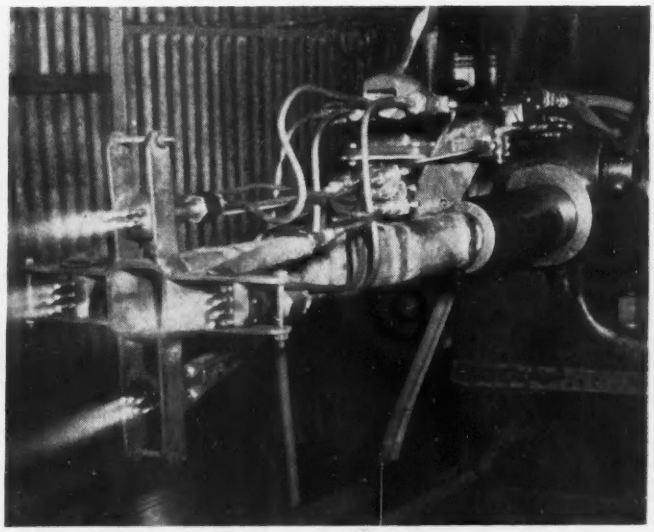
ing the upper end about, he must push and pull the heavy assemblage of block, hook, elevator and bails, which often weighs as much as 40,000 pounds.

The derrickman's job is made lighter in the case shown by a helper who stands on a specially made stabbing board placed on the next girt above the derrickman. From this point, the helper can assist the derrickman in moving the heavy tackle so that the pipe threads feed evenly as the joint is tightened.

The stabbing boards are made of 3-inch pipe welded together to form a frame spanning the derrick, and are about 2 feet wide. To eliminate the spring in the stabbing board, legs are welded to the bottom side in the center and steel rods are welded as a brace to reinforce the pipe on the long span. The surface is covered with expanded metal to provide a non-skid surface and to permit the floor crew to see what the derrickman is doing.

HOW TO—Flame-Harden Tool Joints

A method of increasing the Rockwell hardness and the useful life of tool joints of varying size without an elaborate array of equipment and large investment was provided by one oil field tool shop that fabricated an efficient setup to flame-harden such tool joints. The equipment consists of a hollow spindle lathe, 4 heating heads manifolded to oxy-acetylene heating blowpipes as shown, and 2 compressed air quenching nozzles.



—Photo courtesy the Linde Air Products Company

A 4-jaw chuck rotates the tool joints while the blowpipes and quenching tube remain stationary on a 4-arm bracket mounted to a salvaged section of square kelly. The kelly fits on the lathe spindle, which can be positioned at close range to the tool joints, and can be quickly withdrawn out of the way to permit removal of the hot tool joint and insertion of a new joint.

Flames heat the face of the tool joint to about 1500° F., after which the flames are killed and blasts of compressed air quench the joint. Rockwell "C" hardness of the face is increased from 25 to 45 points. Depth of hardness is about ⅛ inch, enough to help the face of the joint resist wear during drilling operations. The entire hardening process requires only about 1 minute.

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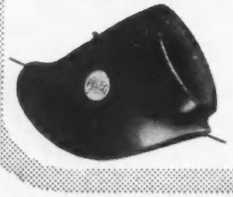


MULTIPLE PACKING of Input Wells

By W. A. HESSIN

Petroleum Engineer
Pennsylvania Oil and Gas Management Associates

REGULATION OF pressures and volumes admitted to as many as 5 sands through one well is accomplished through use of multiple packers and multiple macaroni strings of tubing between surface controls and sand-face areas. The author describes and illustrates a system which offers a solution to the problem of variable, multiple repressurings in multi-zone recoveries.

THE pressure input well has proved to be the economic factor in secondary recovery of oil with recovery efficiency regulated by application technique of the pressure medium as well as the pool location of the well.

The mechanics of the input well have developed from the early days of secondary production when pressure was applied to the sand face through the well casing or a single tubing string to present-day practice of multiple-packing the face of the producing sand and applying controlled pressure to individual zones between the packers. Variable permeability found throughout the oil sands of Western Pennsylvania necessitates the use of a systematic application of energy (air/gas) from an external source to prevent an early breakthrough of one section of the sand body leaving the remaining vertical sections unaffected.

To serve as an aid in the advancement of higher efficiency at the input well and to demonstrate the present advantages of surface control of multiple-packers and the relative sand sections, a description is presented of the equipment used and the procedure of installation for pressure control of an actual five-zone input well now operating in the Third and Fourth Venango sands of Warren County, Pennsylvania.

Equipment Used

The commercial packers used in this case are balloon pressure type for a 6¼-inch hole, each consisting of a hollow steel body with a cylindrical expanding rubber 24 inches long mounted on the exterior of the packer body and between the shouldered ends. The top and bottom of the rubber are attached to the packer body with the center section left free for ballooning action. Small vents are placed at the center of and through the body to transmit expanding pressure to the rubber. The tubing connections at each end of the body are six inches long to provide for ease in removal by fishing, if necessary.

The tubing is comprised of one three-inch and five ⅜-inch inside diameter strings. The three-inch tubing is employed to lower the packers and repressure assembly into the drill hole and to provide a pressure string for packer expansion. The three-eighths-inch tubing provides for separate pressure lines to each sand interval formed by the packers. The five ⅜-inch strings are contained within the three-inch tubing and each is connected to a separate sand zone by the use of a vent nipple placed just above each of the four lower packers and an unloading or dump nipple located just below the bottom

About the Author

W. A. HESSIN was graduated from the University of Oklahoma in 1942 with a B. S. degree in petroleum engineering. After serving for 43 months during the war with the Army Corps of Engineers, he spent 2 years as a petroleum engineer with Mene Grande Oil Company in western Venezuela. He has been working in secondary recovery operations for Pennsylvania Oil & Gas Management Associates since returning from South America in 1948.

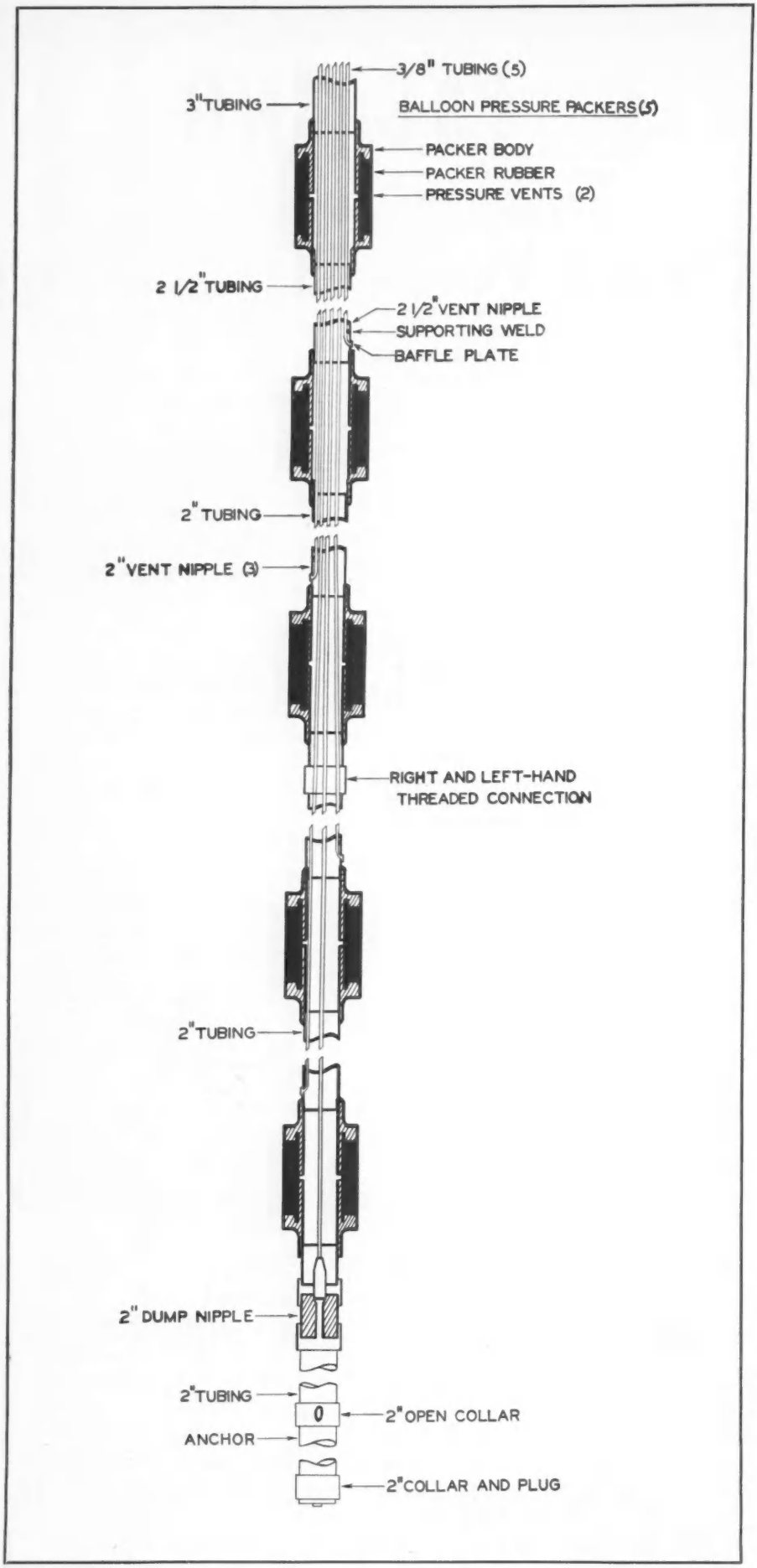


FIGURE 1. Multiple packer assembly.

packer. As shown in Figure 1, the outer tubing and packers are tapered in size from 3-inch to 2-inch according to the number of three-eighth-inch strings to be accommodated.

Each vent nipple consists of a ten-inch tubing nipple of a diameter corresponding to the tapered string size with a three-eighth-inch hole drilled through its wall four inches from its bottom end. A two-foot length of three-eighths-inch tubing with a short bend at the lower end is placed inside the larger tubing, is fitted and welded to the perimeter of the drilled hole in the larger tubing and is spot welded for support between the two nipples near the upper end of the larger nipple. A small baffle plate with top and bottom openings is welded to the outer surface of the larger nipple and over the drilled hole to prevent jet action against the sand face.

Dump Nipple

The dump nipple placed in the larger tubing string and immediately below the bottom packer has a two-fold purpose. It is connected to the longest three-eighths-inch string for pressuring the bottom sand zone and is also used for releasing or dumping the fluid used in the larger tubing for packer expansion. It consists of a solid steel nipple with a three-quarters-inch hole drilled through its length. The hole is enlarged to one-inch diameter at the upper end and is provided with left-hand threads. The bottom of the three-eighths-inch tubing is swaged out to one inch and is also left-hand threaded to accommodate the threads in dump nipple. If, for some reason, it is found necessary to remove the multiple-packer assembly from the well, the three-eighths-inch tubing connected to the dump nipple is rotated to the right at the surface until the connection at the dump nipple is disengaged. The fluid contained in the larger tubing for packer expansion is thus emptied into the well pocket below the bottom of the sand and the packer and tubing assembly may be easily removed from the well.

An open collar is used in the larger tubing below the bottom packer and at a point opposite the bottom of the producing sand body to provide for pressuring the bottom zone.

A surface seal between the three-inch and three-eighths-inch tubing is made by using a small packing head equipped with a three-inch connection on the bottom and five individual holes through its body to accommodate the three-eighths-inch tubing. Individual rubber packing, follower rings and an adjustment lid provide a packing gland about each three-eighths-inch tubing string. This head is used to

prevent fluid loss in event of a pressure leak and to serve as a seal if additional external pressure is to be added to the three-inch tubing for packer expansion.

Assembly and Installation

All of the larger tubing to be used between packers is cut to provide proper spacing of packers as derived from the electric well log, core analysis and drill cuttings. Assembling the packer sections in conjunction with fitting the three-eighth-inch tubing within the sections is done on the ground surface. As the overall length of the entire packer assembly exceeds the height of a drilling machine mast, the unit is assembled by sections in the following order: (1) the anchor, open collar and tubing below the dump valve are suspended in the well casing at the surface; (2) the next section, consisting of the two bottom packers and dump valve, is then connected; (3) another two-packer section including the 2½-inch vent nipple is connected to (2) by the right and left-hand threaded connection, and (4) the remaining 2½-inch tubing and top packer is added. An insoluble thread compound is used on all connections throughout the entire packer assembly and tubing.

The packer and tubing assembly as shown in Figure 1 is tested for connection leaks by lowering the unit into the well casing, connecting the packing head to the top of the three-inch tubing or tubing nipple and applying pressure to the three-inch tubing by a tee connection. All of the three-eighths-inch tubing strings should extend through and above the packing head and should be left open at the ends. Thus, the pressure used expands the packers to the limits of the inside diameter of the casing and any leaks may be detected by a blow at the open ends of the three-eighths-inch tubing or, if the external source of pressure is closed off, a pressure gauge may be used to detect any faulty connection including the dump valve. The test should not be performed in casing having an inside diameter greater than the expanding limits of the packers, nor should the test pressure be built up to exceed the casing strength or the packer manufacturer's recommendations.

A double precaution is taken in running the three-eighths-inch tubing while lowering the packer assembly to the bottom of the hole. The three-eighths-inch tubing extending above the top packer in the assembly is cut to five different lengths in order of height to correspond to the five pressure zones with the ends of the tubing contained within a comfortable vertical working range. Each three-eighths-inch string is then painted with a contrasting color to provide a second preventative against mixing the tubing and eventually the zones upon completion of running the tubing.

All of the tubing is prepared previous to running it into the hole by placing five joints of three-eighths-inch tubing of equal length inside each joint of three-inch tubing and marking the three-eighths-inch tubing near each end with the contrasting paint. Each joint of three-inch tubing containing the five joints of three-eighths-inch is then raised over the well; the three-eighths-inch strings are matched by color and connected preceding the connection of the larger tubing. The tubing is thus successively run until the two-inch anchor is set on bottom.

The three-inch tubing is capped at the surface by sliding two nipples, a union, a tee and the packing head over the three-eighths-inch tubing. The tee is used to fill the tubing with packer expanding fluid, to provide a pressure gauge connection and, if necessary, to connect to a pressure supply. The union is necessary to make the final connection in the larger tubing (Figure 2).

Balloon Packers

The balloon packers are hydrostatically expanded by filling the three-inch tubing with used lubricating oil (or other inert fluid) providing a constant pressure head on the packers and serving as a preventative of tubing corrosion and as a "cushion" in the event that more pressure (gas) must be supplied to exceed that imposed by the medium on the sand face. The annular space between the three-inch tubing and the well bore is filled with water to a sufficient height to provide hydrostatic pressure on the top exterior

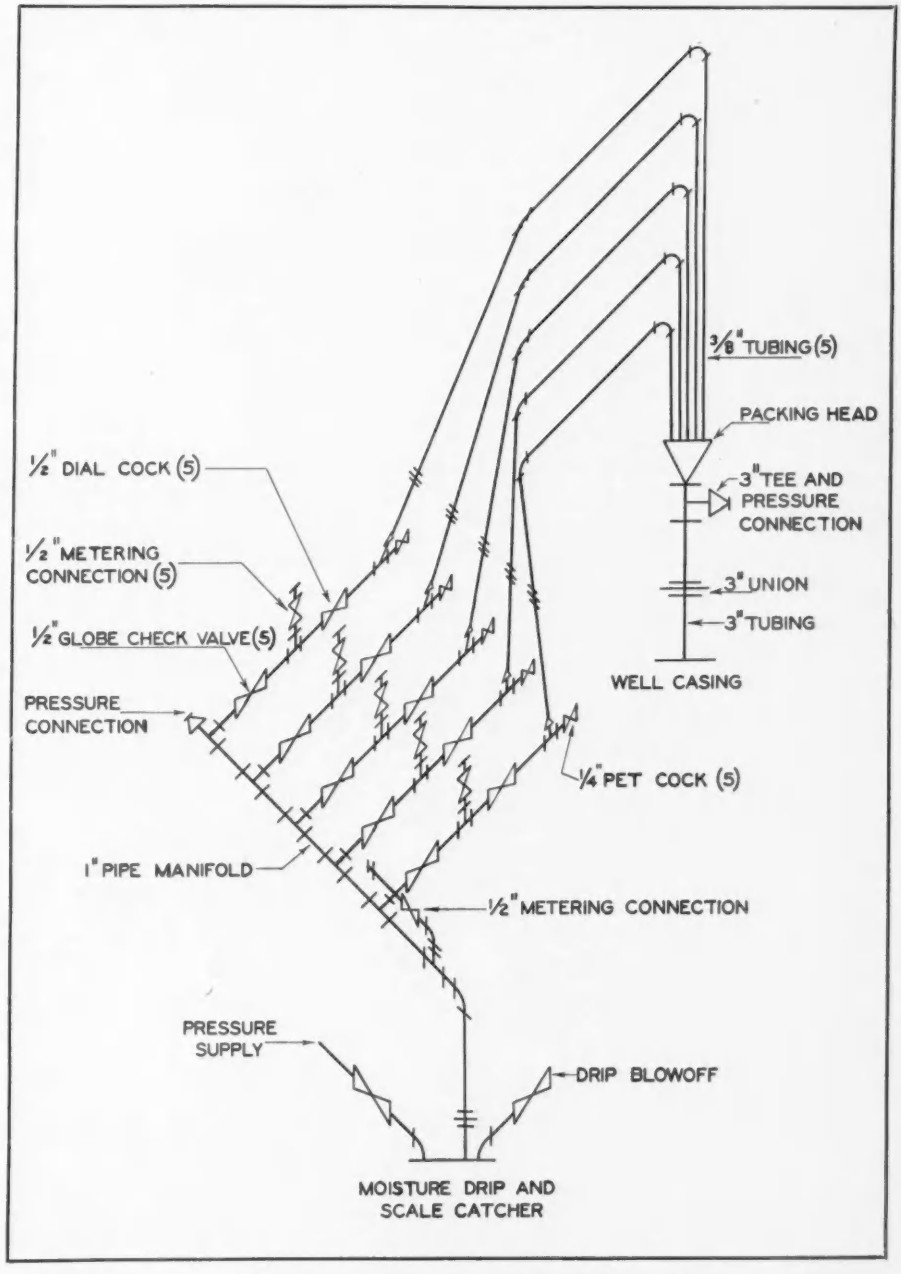


FIGURE 2. Well head and metering manifold.

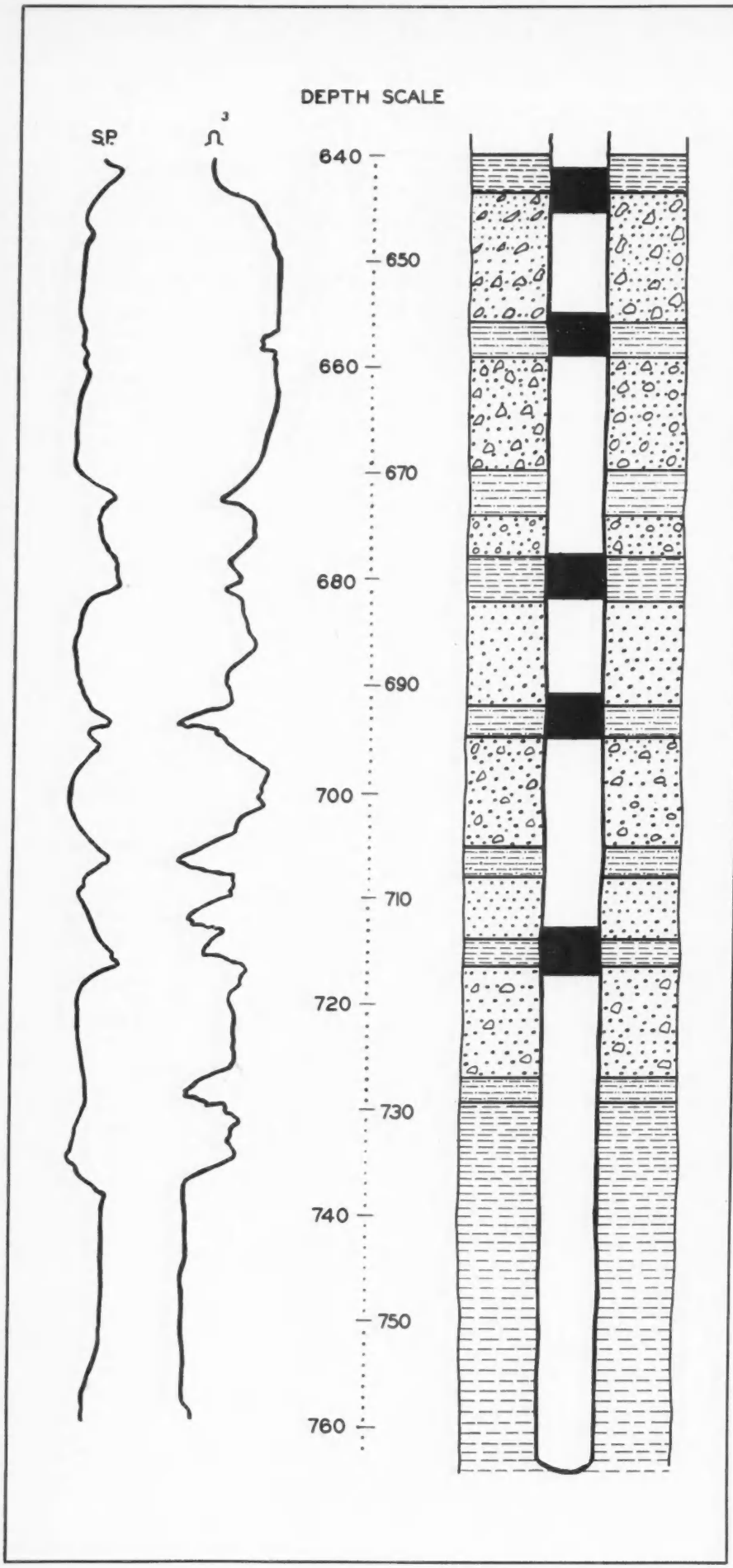


FIGURE 3. Electric well log and packer settings.

of the top packer rubber to minimize the pressure differential at this point.

The repressuring medium (gas) is introduced to the well by means of a metering and regulating manifold (Figure 2). Each string of three-eighths-inch tubing extending above the packing head is connected separately into a common one-inch manifold which is directly connected to the pressure line from a compressor plant. The three-eighths-inch tubing lines are swaged out to one-half inch and a dial cock, one-half of a metering by-pass connection and a globe check valve are placed in the pipe run before entering the manifold. A connection for a portable meter is also provided in the manifold so that the meter may be solidly attached by pipe union to this connection and, with the aid of a flexible hose attached to and downstream from the meter, any one zone may be metered individually while the remaining zones are being pressured simultaneously.

Depth and Pressures

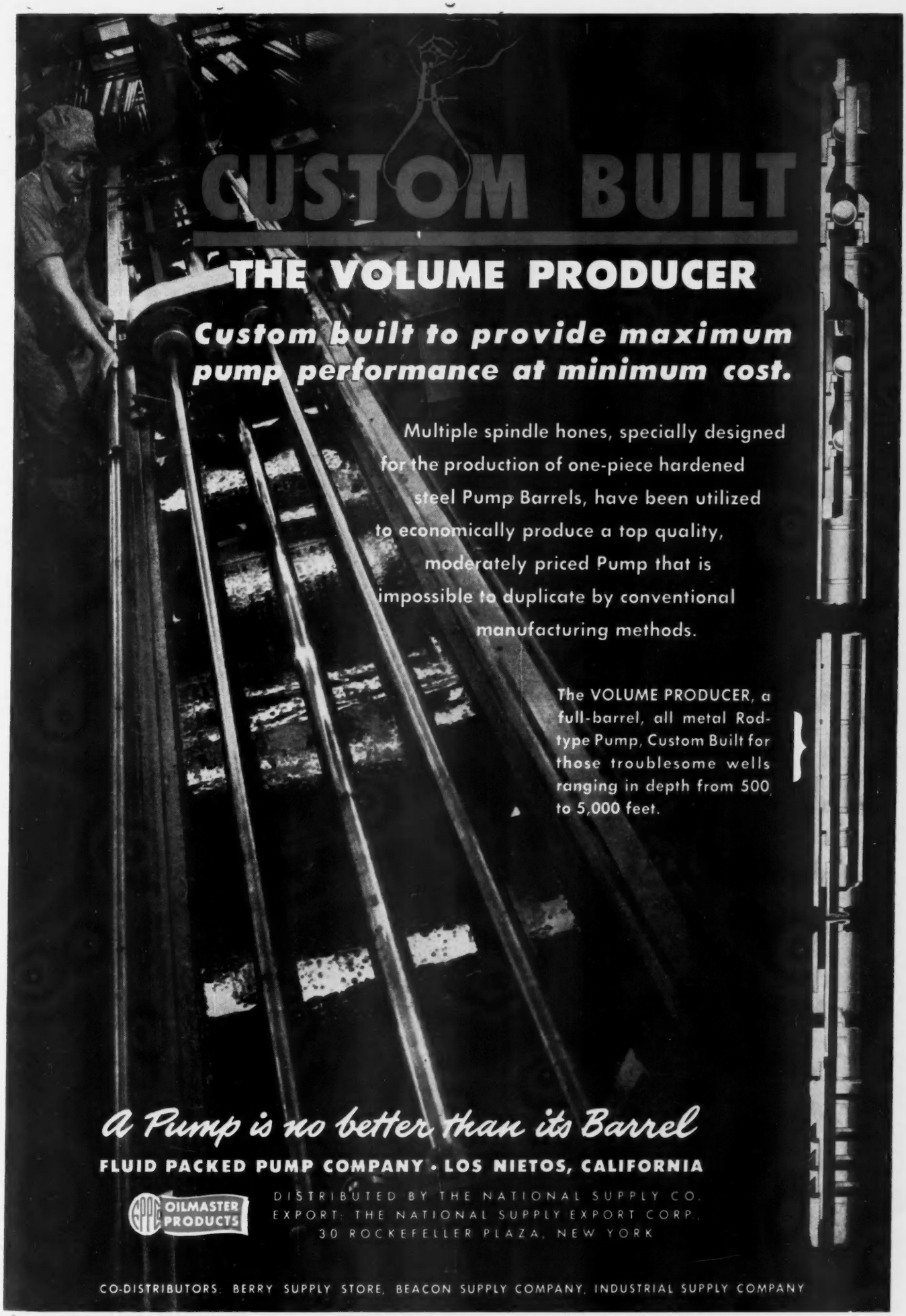
The depth of the well and the injection pressures govern whether or not the tubing should be anchored at the surface. The size of the larger tubing is also dependent on the number of three-eighths-inch strings to be run. It is entirely feasible to use more balloon packers and pressure tubing strings if smaller zoning of the sand body is found necessary.

From Figure 3 it will be seen that the Third and Fourth Venango sands are contiguous presenting a total sand body over 80 feet in thickness. The electric well log and corresponding packer settings in the well bore stress the evident need for zoning of the sand body. Core samples taken from this well show a variance in dry permeability between zones of as much as 2000 millidarcys.

This type of input well multiple-packing, tubing design and well head metering provides positive control in input volume regulation as well as packer setting by surface control. By proper surface regulation of input volumes the pressure medium is introduced to each section of the sand face in accordance with the sand characteristics and by-passing or channeling is maintained at a minimum. As more of the sand face is pressure controlled and a pressure drive is exerted over the entire vertical sand section, more of the reservoir fluids will be affected and an ultimate higher recovery may be expected.

ACKNOWLEDGEMENTS

The writer wishes to thank Larkin & Company, Butler, Penn., for cooperation extended in the development of well equipment and Jack Litzinger, head toolpusher, Pennsylvania Oil and Gas Management Associates, Oil City, Penn., for field supervision in the installation of the subject matter.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CORE ANALYSIS PROBLEMS in Secondary Recovery

By RAY STAPLES

Petroleum Engineer, Cable & Stine, Wichita Falls, Texas

THE AUTHOR points out the need for accurate sampling of a formation—preferably when the field is first being drilled up—and subsequent thorough study of the cores to determine such characteristics as porosity, permeability, fluids viscosities, oil saturation and effect of drilling fluids on formation.

TO AVOID commercial failures of secondary recovery projects, it is imperative that ultimate recoverable oil calculations be determined with accuracy. Core analysis is fundamental to secondary recovery calculations and the solving of problems pertaining thereto, although some projects are haphazardly developed without the aid of this useful engineering tool. Calculated secondary recovery reserves based on primary recovery, an old but current method, are frequently in error and are responsible for many unprofitable projects, although all failures cannot be attributed to this cause. A thorough knowledge of sand conditions acquired from a representative number of cores is essential to efficient development and profitable operation.

If reliable core analysis data are available, it is possible to determine the ultimate recoverable oil by secondary recovery methods, the optimum well-spacing and injection rates, a shooting and casing program, specifications for a gas or water plant, the time required before secondary recovery results will be noticeable, and the life expectancy of a project.

The chief problem in core analysis is sampling and interpreting the data, since actual laboratory tests are not difficult. Where uniform formations are experienced over the entire zone being analyzed, sampling is not so important, but where stratification and changing sand characteristics occur, extreme care is required in sampling in order to avoid erroneous interpretation. At least one representative sample should be selected from each foot of the zone in question. The samples should be sealed in air tight containers immediately after having been taken from the core barrel, and delivered for analysis as soon as possible. Obviously any loss of fluids, oil or water, seriously affects the calculations and predictions. The importance of full core recovery can be seen easily since incomplete data may be misleading and can result in erroneous conclusions. The excellent recovery obtained by using diamond core barrels make this manner of rotary coring attractive although the cost may be greater.

Interpretations should be tempered not only with good judgment, but also with knowledge acquired from field experience, because many variables frequently are encountered that cannot be properly accounted for by laboratory data alone. Therefore, all theoretical calculations and various formulas based on core data should be used as fundamental guides for future development, but not necessarily as the basis for final decisions pertaining to development problems.

Porosity and Permeability

Porosity, a measure of the fluid capacity of a solid, is expressed in percentage or in barrels per acre-foot. The more important factors controlling porosity in sand reservoirs are average grain size and the degree of cementation. Porosity determinations are essential to complete core analysis; otherwise values of fluid saturation cannot be placed on a comprehensive basis. For convenience, some operators are inclined to estimate the commercial value of a property on the number of barrels of oil in place per acre-foot. Reasoning on such basis is obviously subject to error and may result in the development of an unprofitable project. The recoverable oil is that quantity which can be recovered by a given method of operation and is not necessarily a percentage of the volume of oil in place.

Permeability, a measurement of the fluid conductivity of a solid, should be determined both vertically and horizontally. The importance of vertical permeability can hardly be overemphasized because zones of low oil saturation, such as gas zones, or zones where gravitational drainage has occurred, or watered out zones, or zones comprised of carbonaceous material, are hazardous to secondary recovery operations and must be detected because some of them act as "thief-zones." Consequently, the success of a project depends on whether these zones, if present, can be isolated successfully. Any appreciable vertical permeability will defeat attempts to isolate such thieving zones.

Horizontal permeability is extremely important in recoverable oil calculations, gas-oil and water-oil producing ratio predictions, well-spacing, and completion programs. Horizontal permeability measurements are employed to calculate the injectivity rates used in determining the optimum well-spacing, to estimate the required surface pressure, and to determine the degree of stratification in the reservoir.

A stratified oil-bearing formation has an important relationship to the ultimate recovery by secondary recovery methods. Measures of sand stratification, sometimes termed stratification constants, are ranges in permeability. Permeability variations of oil-saturated zones determine

About the Author

RAY STAPLES graduated from the University of Tulsa with a B.S. degree in petroleum engineering and in 1941 was employed as a petroleum engineer in charge of a water-flood project in Southeastern Kansas. He resigned from this position to accept an appointment as petroleum engineer with the U. S. Department of the Interior. In 1944 he became associated with Cable & Stine, Wichita Falls, Texas, and recently was made a partner in the firm.

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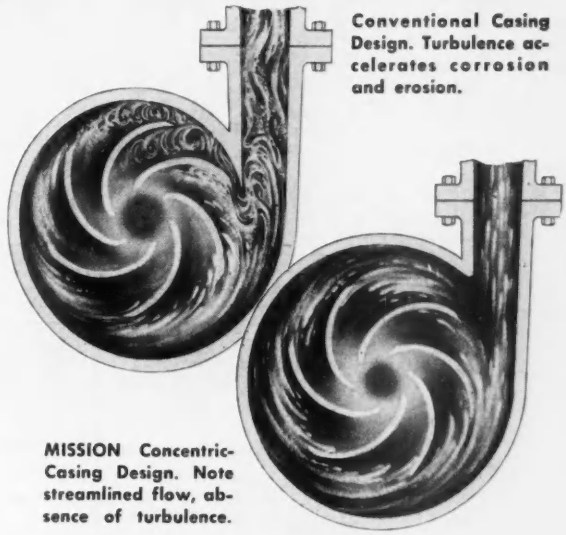
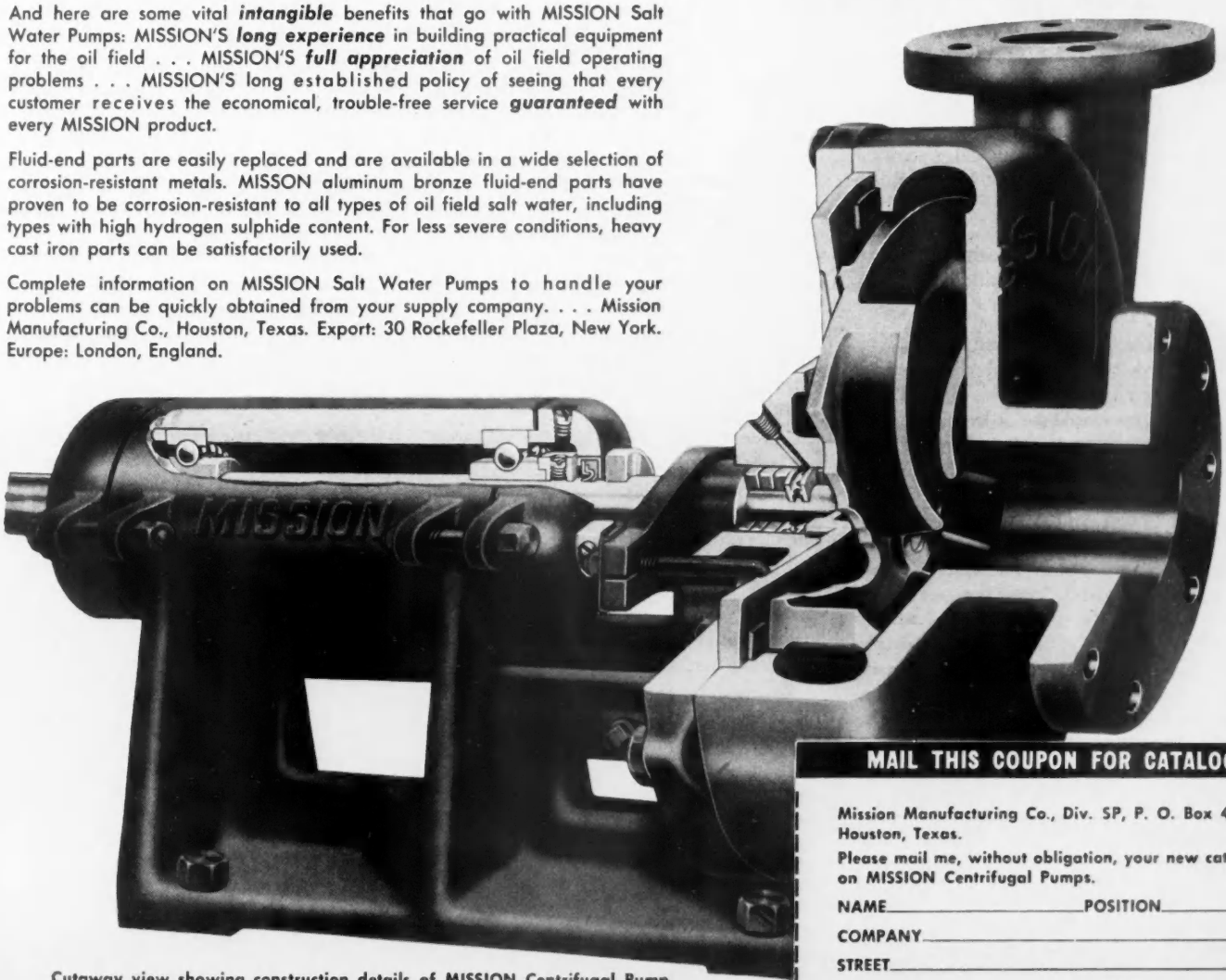


Conventional Casing Design. Turbulence accelerates corrosion and erosion.

MISSION Concentric-Casing Design. Note streamlined flow, absence of turbulence.



Cutaway view showing construction details of MISSION Centrifugal Pump.

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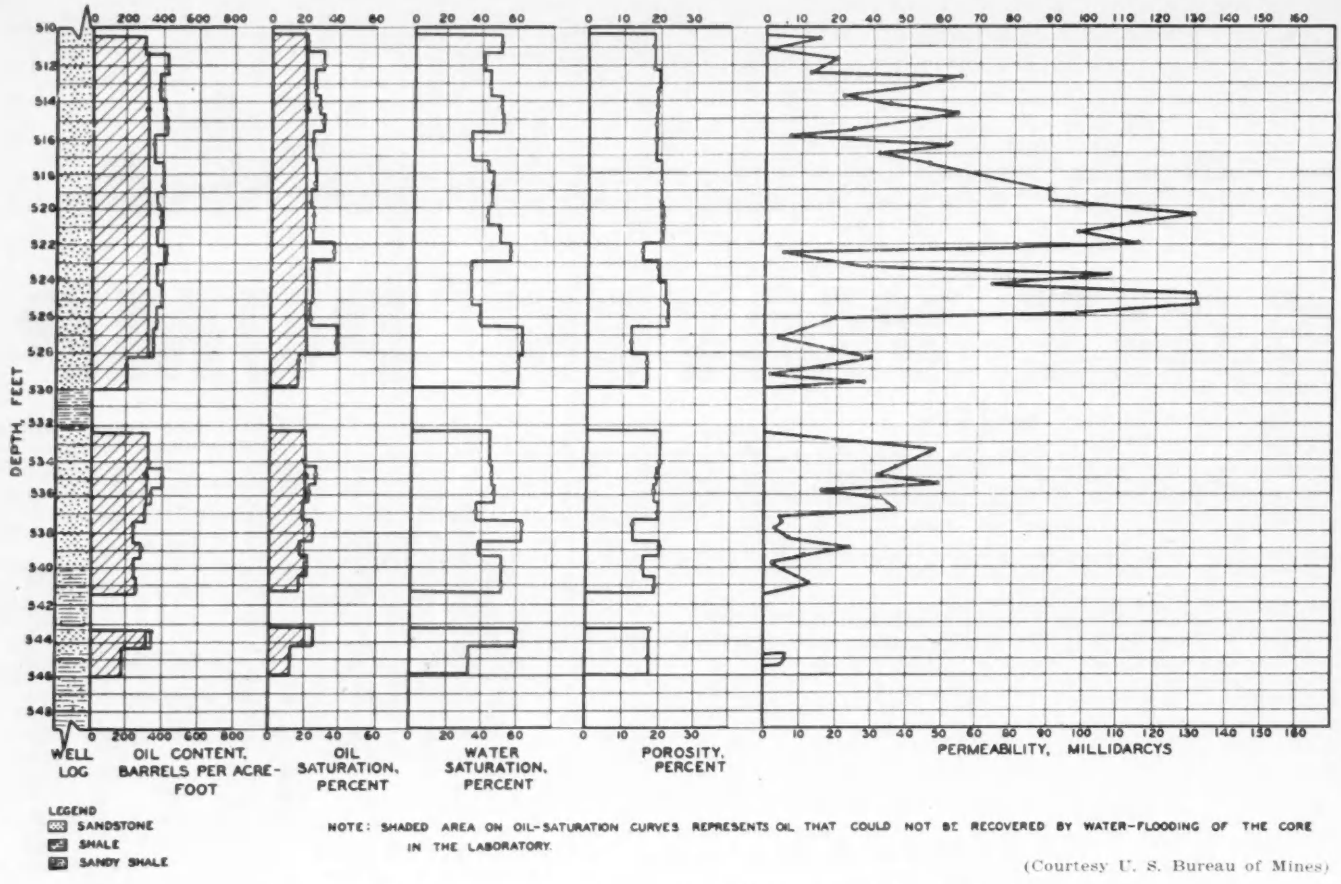

(Courtesy U. S. Bureau of Mines)

Analysis of a Bartlesville sand core from well in 36-26n-16e, Nowata County, Oklahoma.

the possible efficiency or percent of theoretical recovery. The "Rule of Thumb" recovery prediction in regard to sand stratification is 10 to 1; that is, recoverable oil by secondary recovery methods will not be realized from oil saturated zones having permeability less than 10 percent of the maximum permeability measured. For this reason the importance of having permeability data can be readily seen in predicting secondary recovery oil.

Viscosity and Oil Saturation

Oil viscosity may not be considered a part of tabular core analysis data. However, it is essential to a complete and comprehensive reservoir study of any secondary recovery project because it bears a direct relationship to recovery. Its importance can be as great as that of permeability, especially in depleted reservoirs which have a more or less fixed oil viscosity. Some compensations for unfavorable permeability can be made by shooting, acidizing, or changing the well-spacing, but oil viscosity can be changed only by change in temperature and gas in solution. Oils successfully subjected to secondary recovery by water injection are known to have viscosities as high as 35 centipoises; on the other hand, to the writer's knowledge, the maximum viscosity of an oil to which secondary recovery by gas injection has been applied successfully is lower, probably ranging between 20 and 25 centipoises.

Unquestionably, the determination of true oil saturation as it exists in the reservoir is the most important single item in core analysis. In planned secondary recovery operations, the margin of profit or loss depends upon the accuracy of this determination. The ideal solution to the problem is to obtain unflushed cores or to minimize the flushing action to such a low degree that the fluid saturations are reliable. If this can be accomplished, subsequent recovery data obtained in the laboratory become very useful.

Conventional rotary or cable tool coring methods using water-base drilling fluid generally flush the core to a point where the oil saturations are at the irreducible minimum; consequently, the oil and water saturations of such cores are of little value. Variables that influence the degree of flushing are the type of drilling fluid used, the permeability of the formation, and the oil viscosity.

To obviate the difficult problem of obtaining unflushed cores one must determine with accuracy the degree of flushing or use oil or oil-base drilling fluid, or reduce the water loss in water-base drilling fluid to zero. The latter two methods may result in some degree of flushing, depending on the specific conditions. Indirect calculations may be utilized to determine the percentage of oil saturation if sufficient production data such as gas-oil and water-oil ratio histories and recoverable oil are known. Some engineers prefer the indirect method of calculating the percentage of oil saturation because of the flushing hazard involved when employing the oil saturation as actually determined in the laboratory.

The information required to develop a field properly should be obtained while wells are being drilled. This pertains to core analysis as well as other physical tests which represent valuable engineering data. Hence, well completions should be made with pressure maintenance or repressuring in view, because the recoverable reserves are increased substantially in reservoirs which are susceptible to either method. The percentage of increase in recovery can be as high as 150 percent, a fact which becomes attractive considering the current cost of new discoveries. Moreover, data can be obtained more economically at time of drilling, and core analysis information can be used to advantage in well completion and reservoir studies as well as later determining the possibility of secondary recovery operations. Furthermore, it must be kept in mind that full core recovery and complete analyses are absolutely necessary for a thorough knowledge of the reservoir.

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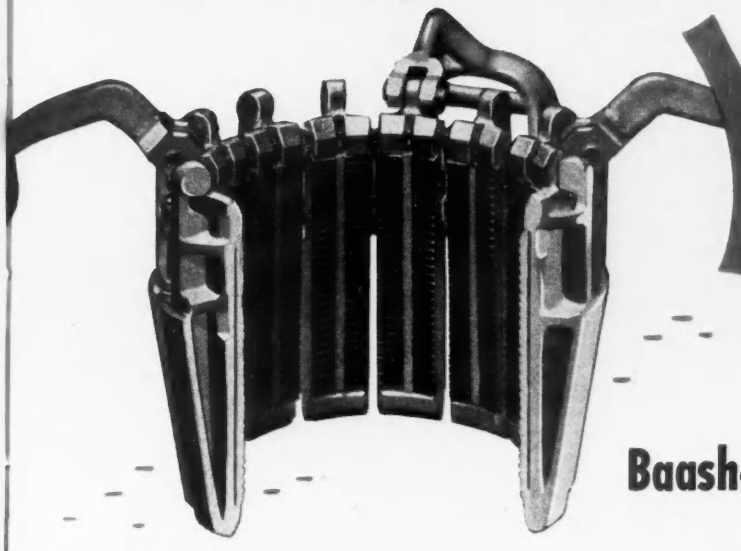

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Baash-Ross Type "UC" Casing Slips

BECAUSE A STRING of casing has a relatively thin wall in relation to its diameter, it is much more easily damaged by unequal slip pressure than are drill pipe or tubing. Yet the weight of a string of casing—particularly under modern deep-hole drilling operations—can be extremely great . . . *so great, in fact, that even a slight misalignment of the slips or a moderate concentration of slip pressure can cause serious damage to the casing and might even result in losing the casing string down the hole.*

But such risks are now minimized through development by Baash-Ross of a new type of casing slip—the Baash-Ross Type "UC" Casing Slip. The Type "UC" Casing Slip consists of multiple segments, flexibly linked together so that they *w-r-a-p* around the casing like a chain tong to fit the exact curvature of the casing. Each individual slip segment takes the *same* uniform grip on the surface of the casing because *all* of the segments are unitized together—*act* as a unit, *set* as a unit, *grip* as a unit. This assures uniform slip pressure around the full circumference of the casing, eliminating risk of concentrated pressures that crimp the pipe and egg-shape the casing.

THREE BASIC BODY SIZES HANDLE WIDE RANGE OF CASING DIAMETERS

And here's an important point . . . Only *three* basic body sizes of "UC" Casing Slips are needed to handle *all* popular casing sizes from 7⅝" through 13⅜". As shown in the accompanying table, interchangeable liners are available for each of the three basic body sizes so that each size can be readily adapted to fit different casing sizes within its operating range . . .

Basic Body Size "UC" Casing Slips	13⅜"	10¾"	9"*
Interchangeable liners available to fit	13⅜" 11¾"	10¾" 9⅝"	9" 8⅝" 7⅝"

**Fits bore and taper of standard rotary table.*

LINERS EASILY REPLACED

The liners in "UC" Casing Slips have ample length and are so designed that they will cut through pipe scale and any surface coating on the casing to take a firm, slip-proof grip *without damaging the surface of the casing itself.*

And if at any time after long usage, the liners become dull—or when changing from one casing size to another as outlined above—they can be quickly and inexpensively replaced. Simply pull a stainless steel pin, replace the old liner with a new one, slide the pin back in place and the job is done. The stainless steel pins eliminate risk of corrosion and assure easy liner replacements. Furthermore, it is important to note that none of the load of supporting the casing string is placed on retaining pins, bolts or any other parts that can become sheared or lost in the hole. *For maximum safety and strength all weight on the liners is transferred directly to the Slip body itself!*

HERE IS WHY *every casing job needs the protection of Baash-Ross "UC" Casing Slips!*

Because casing has a thin wall in relation to its diameter, it is easily crimped or damaged by even small misalignments that would not affect thicker-walled drill pipe or tubing.

If casing diameters vary slightly or if the slips are not set at exactly the same level, conventional rigid-type slips cause concentrated slip pressure that can crimp, bottle-neck or squeeze the casing out-of-round.

Such damage not only risks dropping the casing string, but the bulged or egg-shaped areas can cause poor joint make-up as well as tight spots through which tools cannot pass. Moreover, wear concentrated on the bulged spot leads to premature casing failures.

The flexible unitized design of Baash-Ross Type "UC" Casing Slips eliminates risk of one portion setting higher or lower than the other . . . and the multiple narrow segments assure an accurate, safe grip that exactly fits the curvature of the casing.

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Residual Water and Residual Oil

by

Capillary Pressure Technique

By C. D. STAHL and R. F. NIELSEN
Division of Petroleum and Natural Gas Engineering, The Pennsylvania State College

CAPILLARY PRESSURE—saturation curves were obtained for a number of Bradford, Berea, and Venango cores. Certain discrepancies in some of these curves are pointed out, and explanations offered. The relation of the limiting saturations given by the capillary pressure curves to the relative permeability curves is discussed, and certain trends shown graphically. This paper was first presented at the Thirteenth Annual Conference on Secondary Recovery held at the School of Mineral Industries of The Pennsylvania State College, State College, Penn.

THE concept of capillary pressure as related to the retention of fluids by porous media has only recently come into the limelight in the petroleum industry. Much work has been done in developing methods for the direct measurement of capillary pressure as related to the nature of both the porous medium and that of the fluids, and also as related to the degree of saturation with respect to these fluids. The use of such measurements represents one of the many avenues of attack in the attempts to increase our understanding of fluid displacement in oil reservoirs and thus increase the efficiency of oil recovery.

In the commonly used sense, the capillary pressure refers to the difference between the pressure in the non-wetting phase and that in the wetting phase, due to the curvature of the interface. The lower the percent saturation with respect to the wetting phase, the greater the degree of curvature of the interface and hence the higher the capillary pressure. This relation of capillary pressure to saturation has been applied to such things as the vertical saturation gradient in a natural reservoir and the saturation gradient known as the "end effect" in production from laboratory cores.

One of the methods of measuring capillary pressure, and the one that has been used in this laboratory, consists in completely saturating the core with the wetting phase, and then determining how much of the wetting phase is driven out by the non-wetting phase at a given pressure. A material which will allow only the wetting phase to pass must be placed at the downstream end of the core. The pressure to just cause the non-wetting phase to enter is the "displacement pressure." The amount of wetting phase that can be driven out by any practical pressure appears to be limited, the plot of pressure against saturation seemingly approaching an asymptote. This practical lower limit of the wetting phase saturation may correspond to the saturation at which the wetting phase is no longer continuous. It is variously referred to as the "irreducible minimum wetting phase saturation" or "residual wetting phase saturation." Since no more, or practically no more, of the wetting liquid is produced by increased pressure, this saturation is also that at which the relative permeability to this liquid is essentially zero. This will be discussed further.

At the Twelfth Technical Meeting, some results of capillary pressure measurements on Bradford cores were presented.[1] It was pointed out that the curve of capillary pressure vs. saturation became practically vertical, that is, parallel to the pressure axis at a certain satura-

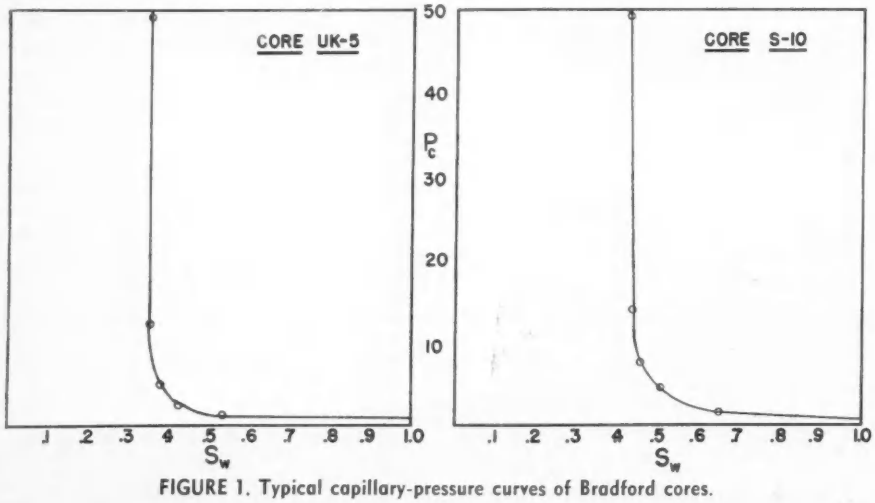

FIGURE 1. Typical capillary-pressure curves of Bradford cores.

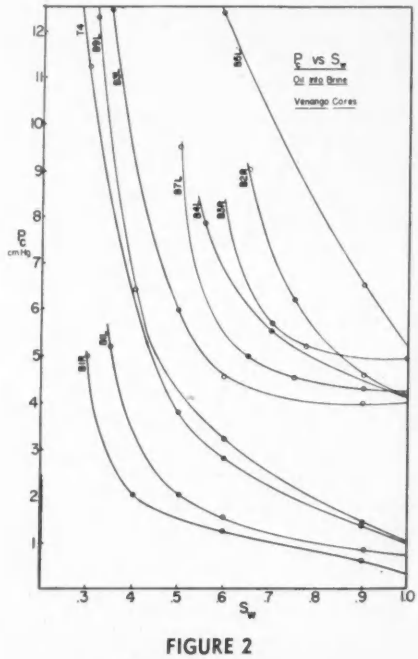

FIGURE 2

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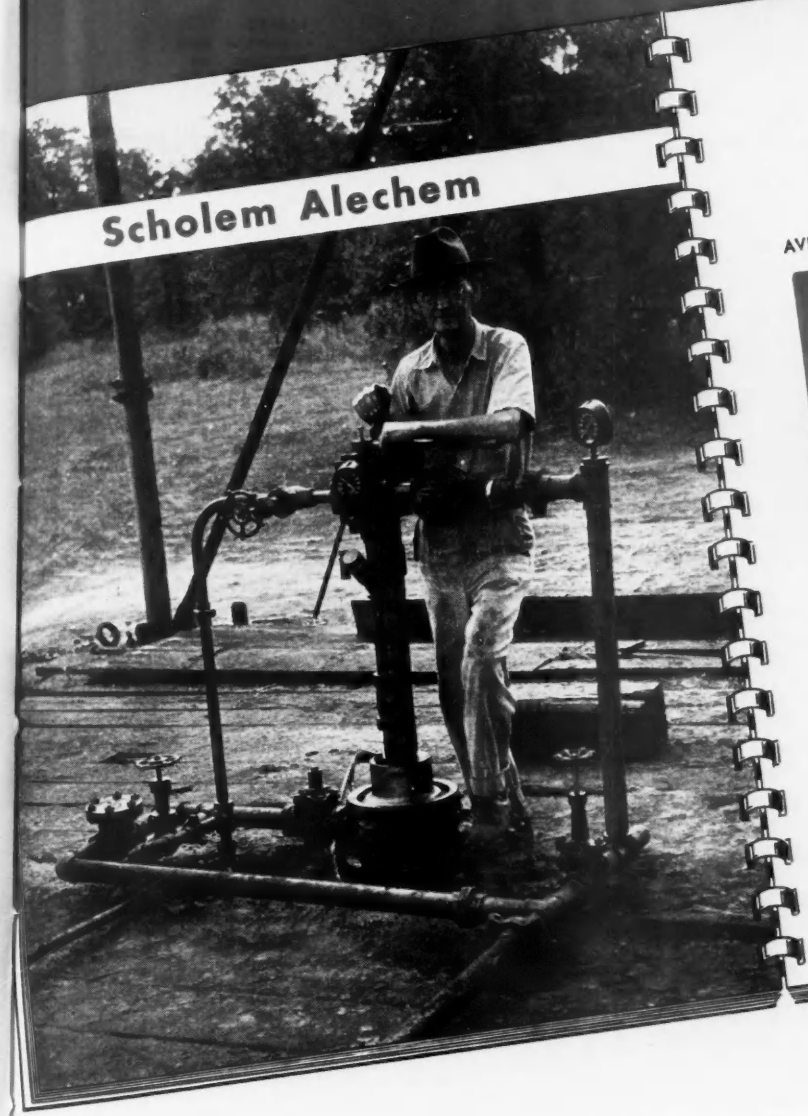
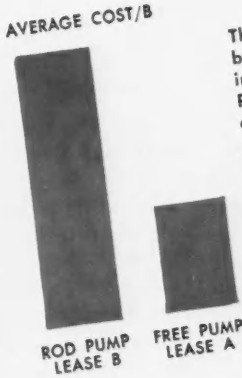


CASE HISTORY

Comparative Production Costs Rod Pump and Free Pump



The figures submitted here were compiled by an operator with two neighboring leases in the Scholem Alechem field, Oklahoma. Producing conditions on both leases are comparable. On Lease B, six wells are being rod pumped. On Lease A, sixteen wells are being Free Pumped. All costs—pumping, pump pulling, paraffin removal, maintenance, and power—were carefully tabulated for a period of six months. The results are shown in the accompanying bar chart and table. The Free Pump wells not only produced more oil—1760 bbls. per month per well compared with 955 bbls.—but their total operating cost per well was lower.

OPERATING COST DATA

	Lease A Free Pumps	Lease B Rod Pumps
Number of wells	16	6
Period covered	6 mos.	6 mos.
Average B/W/M	1760 bbls.	955 bbls.
Cost/W/M	$78.00	$111.00
Total Cost/B	4.5¢	11.6¢

Any way you figure it, production costs are lower when your wells are *Free Pumped*.

Operator after operator is discovering, as this Scholem Alechem operator has proved, that you reduce production costs when you install the *Free Pumping system*.

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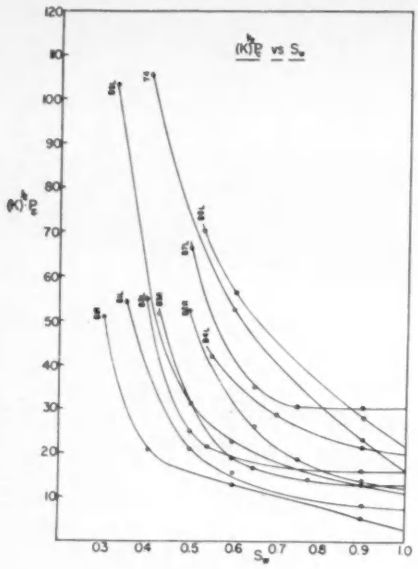

FIGURE 3

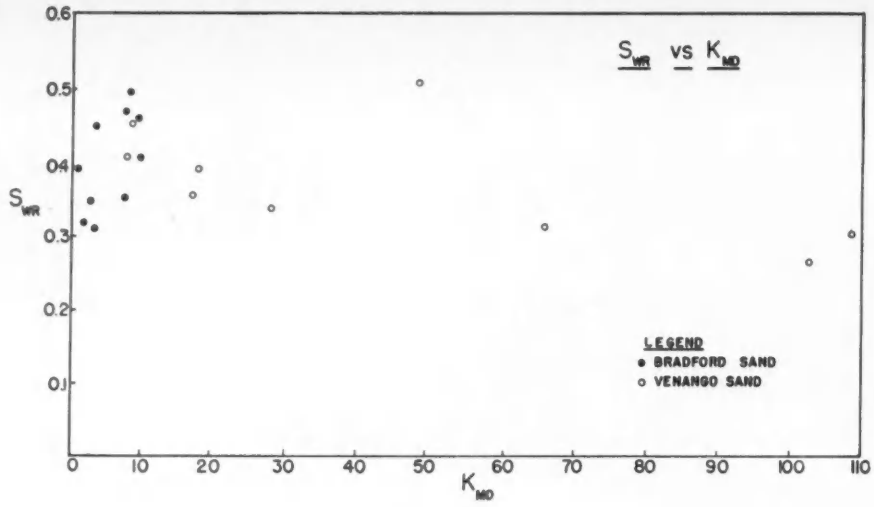

FIGURE 4

tion, indicating phase discontinuity. It was also pointed out that this "irreducible minimum" water saturation was on the average higher than the connate water saturation found by core analyses. This cast doubt on the validity of the capillary pressure method (called by some authors the "restored state method") for determining connate water saturation, at least as applied to the Bradford field. Some possible explanation for the disagreement were discussed. One of these was that the saturations which really corresponded to the higher pressures so far as curvature of the interface is concerned were never reached in the laboratory measurements due to "phase discontinuity" or to the relative permeability becoming essentially zero.

Measurement Sequence

In the experiments reported on at the last meeting, the sequence of measurements was as follows: The extracted core was first saturated with brine, and then the brine was displaced by oil, while a water-wet diaphragm was held against the downstream end. When no more water could be displaced by oil, the water-wet diaphragm was replaced by an oil-wet diaphragm, and a brine flood was imposed. The first set of measurements yielded an oil-brine capillary pressure curve while the second yielded a similarly shaped curve, which became parallel to the pressure axis as no more oil was produced by increased pressure. The vertical part of the latter curve corresponds to residual oil saturation following a water flood. The significance of the lower part of the curve is rather vague in view of the fact that a positive pressure was required to displace oil by water as well as the reverse. This apparent paradox may be connected in some manner with wettability, which is discussed in another paper[2] (soon to appear in WORLD OIL).

The discrepancy between the "irreducible minimum" brine saturation and the connate water content found by core analyses led to a continuation of the capillary pressure measurements in the hope that the accumulation of more data might throw light on the matter. The technique for finding the oil into brine capillary pressure curve was essentially that used previously. As an added precaution against evaporation losses from the measuring pipette, a vial containing a small amount of the same liquid as the pipette was placed over the end of the pipette. Both the pipette and the vial were in a horizontal position, with the open end of the pipette projecting about 2 inches into the vial.

As a further check on the possibility of high residual values due to leaks and evaporation, one run was set up a second time, and a high pressure applied at the start, so as to greatly reduce the time required to reach the "irreducible minimum." The residual water saturation was essentially that given by the complete run. Also, when it seemed that the pressure curve had become parallel to the pressure axis, the pressure was increased to 50 pounds per square inch for a period of 24 hours. In no case was additional brine produced by this procedure.

The procedure for imposing the brine flood on the oil-brine complex was also essentially the same as described previously, as was the material used for the oil-wet diaphragm. Thus residual oil saturations following water floods were determined on all the cores studied.

The present study included 15 Bradford, 10 Venango, and 4 Berea cores. The capillary pressure curves for the Bradford cores were quite uniform in shape. Figure 1 shows some typical curves. Displacement pressures were unexpectedly low considering the permeabilities. Also, the lower limbs were quite flat, that is, a large percent of the brine was displaced by a small applied pressure. The Berea cores were similar to the Bradford cores in behavior. These characteristics of the Bradford and Berea cores may be associated with the relative wettability by oil and water. This is discussed more fully in another paper.[2] The values of the residual brine saturations were, as found previously, all higher than the field connate water saturations found by core analyses. This has already been discussed.

Venango Pressure Curves

The capillary pressure curves for the Venango cores are shown in Figure 2. The shapes are more nearly what would be expected for a water-wet sand than in the case of the Bradford cores. For instance, the displacement pressures are reasonable considering the permeabilities and the oil-brine interfacial tension. Also, the lower parts of the curves are rather typical of those for the water-wet sands.

It may be shown that with a given pair of fluids the displacement pressure, and, in fact, the capillary pressure at any given saturation, should be inversely proportional to the permeability for sands of identical pore structure. While the cores have far from identical pore structures, it was considered of interest to plot, instead of the capillary pressure, the product of the capillary pressure and the square root of the permeability. The resulting curves are shown in Figure 3. They show more nearly equal values of the ordinates at the higher brine saturations than the curves of Figure 2.

Thornton and Marshall[3] showed a

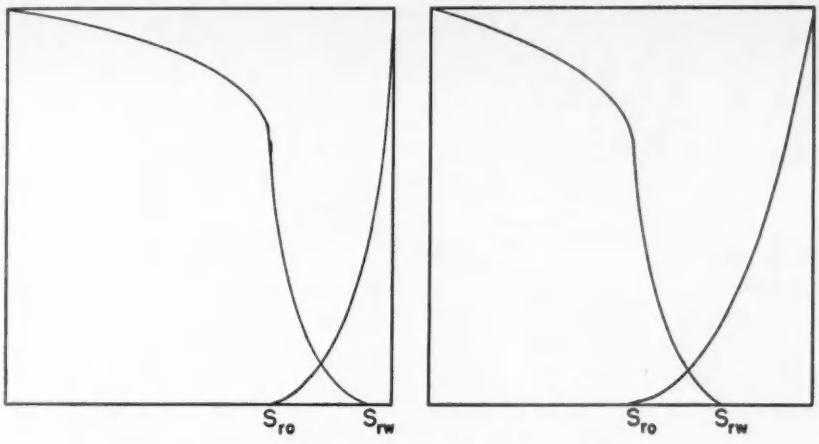

FIGURE 5. Relation between residual water and residual oil.

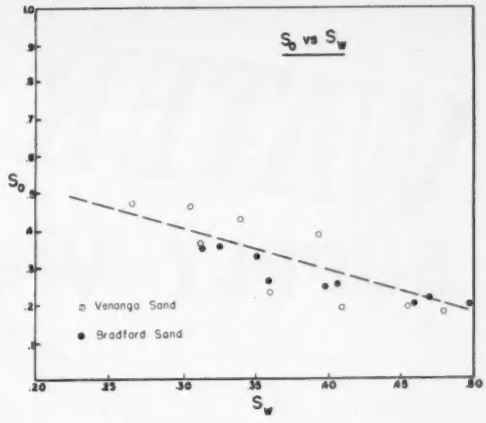

FIGURE 6

trend in favor of higher residual brine saturations in cores of lower permeability. In Figure 4 the residual brine saturation is plotted against the permeability. In the case of the Bradford cores there is not enough of a permeability range to show anything. In the case of the Venango cores one might read a trend into the data in the direction of increasing residual water with decreasing permeability.

Correspondence of Saturations

It is generally believed that high residual water saturations are associated with low residual oil saturations. For instance, laboratory experiments have shown that oil recoveries by air-gas drive are improved by water injection when the water saturation is below that at which the water is movable. Also field experiments are being conducted in which water is injected into sands under air-gas drive. In a recent paper Rose[4] discusses the interrelation between capillary pressure curves and the relative permeability curves for both the wetting and non-wetting phases. He points out the general trends in the shapes of the relative permeability curves. For instance, as shown in Figure 5, the non-wetting phase relative permeability tends to be quite high at wetting phase saturations below the irreducible minimum. The theory is that any immobile wetting phase is in interstitial angles and other places where it cannot hinder much the flow of the non-wetting phase. If the residual wetting phase saturation is high, then, according to Figure 5, the relative permeability curve for the non-wetting phase is shifted to the right so as to preserve its shape and also a sort of symmetry, as Rose expresses it, between the curves for the wetting and non-wetting phases. Thus if the relative permeability to the wetting phase becomes zero at a high wetting phase saturation, the relative permeability for the non-wetting phase becomes zero at a low non-wetting phase saturation.

To see whether the above relation between residual water and residual oil saturations was definite for the cores studied, these two quantities were plotted against each other in Figure 6. The residual oil saturation was that remaining unrecoverable in the core after the oil-brine complex was brine driven while an oil-wet diaphragm impervious to water was held against the downstream end of the core. This residual oil saturation corresponds for practical purposes to the saturation at which the relative permeability to oil becomes zero.

Examination of Figure 6 shows a clear trend in the direction exepcted for both Bradford and Venango cores. It is to be noted that the trend is especially definite in the case of the Bradford cores. Although these cores were all within a limited permeability range, as shown in Figure 4, the residual water saturation varied considerably. The fact that the trend between residual water and residual oil appears so definite tends to verify the experimental values.

It would be of interest to sketch the relative permeability curves on the basis of the above discussion of Figure 5, or even to calculate them from Rose's formulas, were the experimental relative permeability curves been available. It is hoped that the capillary pressure technique may be combined with direct measurements of relative permeabilities on the same cores, to see to what extent relative permeability curves so calculated might agree with experimental curves.

Summary

1. Capillary pressure-saturation curves were obtained from a number of Bradford, Berea, and Venango cores. The experiments included displacement of water by oil followed by a water flood on the complex.

2. The "irreducible minimum" water saturation for the Bradford cores was, in general, higher than the connate water saturations found by routine core analyses. This was attributed to phase discontinuity and vanishingly small relative permeabilities at the apparently limiting saturations.

3. The low displacement pressure and general shape of the oil-water curves for Bradford and Berea cores indicate that these sands are not definitely water wet.

4. The oil-water curves for the Venango cores show definitely a preferential wetting by water. The displacement and capillary pressures for these cores show a tendency to vary inversely as the square root of the permeability in accordance with theory.

5. A plot of residual water saturation against permeability seemed to indicate a slight tendency toward higher residual water saturations with lower permeabilities for water-wet cores.

6. A definite trend of decreasing residual oil staurations with increasing residual water saturations was shown by both Bradford and Venango cores. The relation of this trend to he relative permeability curves for the wetting and non-wetting phases was discussed.

ACKNOWLEDGEMENT

The writers are indebted to members of the staff of the Division of Petroleum and Natural Gas Engineering for many helpful suggestions, and to the Pennsylvania Grade Crude Oil Association for the support of a part of this work.

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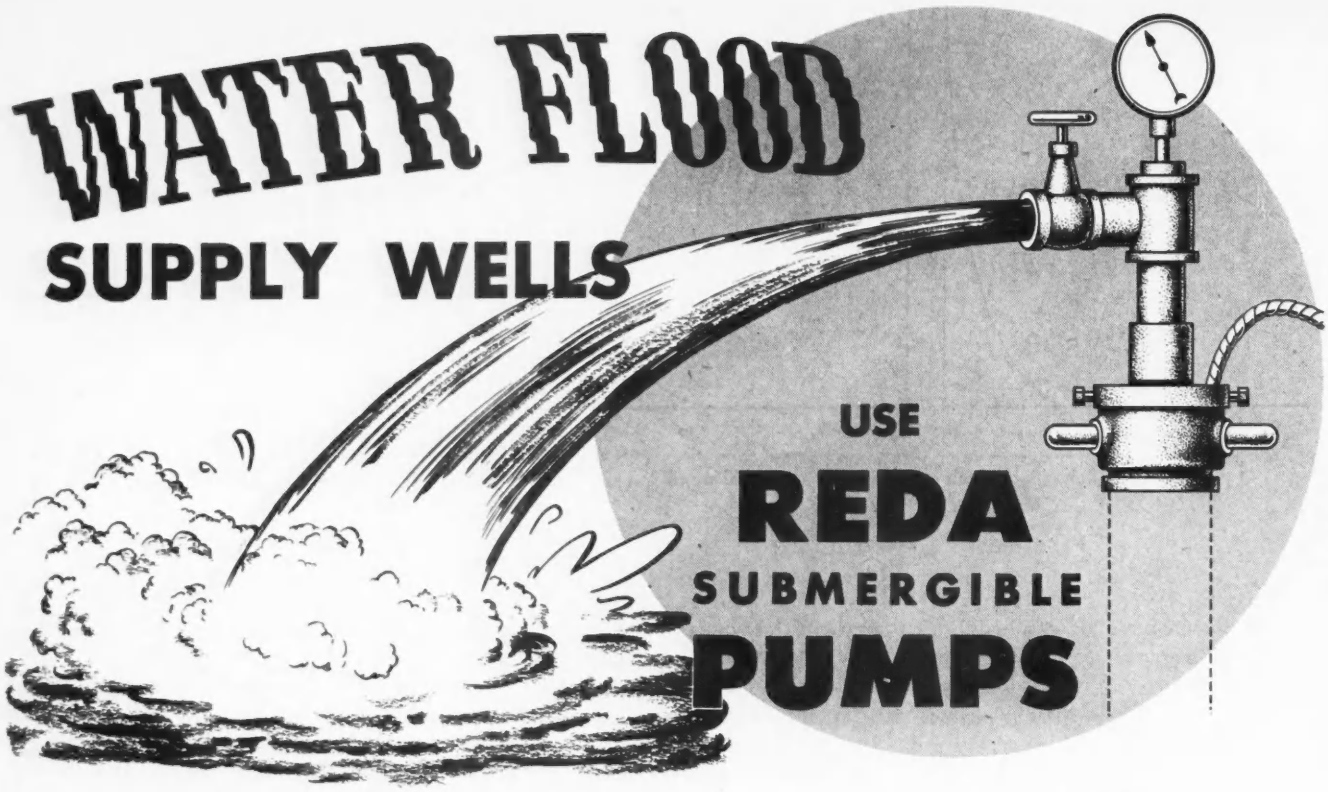
WATER FLOOD SUPPLY WELLS



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BARTLESVILLE, OKLAHOMA

Porosity-Permeability Check by Electric Log

By R. C. BARBER
Schlumberger Well Surveying Corporation

THE APPALACHIAN region, and especially the Bradford area, presents such diverse production problems that it is considered an excellent proving ground for new engineering practices, particularly as applied to secondary oil recovery. Many lessons learned in this area have been successfully applied in other marginal oil fields throughout the country. This is especially true in the science of water flooding where the technique was officially sanctioned nearly 30 years ago although it had been practiced surreptitiously for many years before its legalization.

THE SUCCESS of a water flood rests primarily on the ability of the operator to inject the flood water into the proper zones under the most efficient pressures so as to assure the continued movement of a bank of oil ahead of the flood. This condition, therefore, makes a true determination of porosity and permeability of the zone or zones to be flooded a key factor in planning the project.

The following describes the investigation of porosity and permeability by electrical logging in the Bradford field with the thought that conclusions drawn therefrom may have application in other areas having analogous or near-analogous conditions.

The Bradford field comprises approximately 92,000 acres within a rectangle 21 miles long in a north-south direction and 18 miles wide east and west, located approximately 160 miles northeast of Pittsburgh.

As shown in Figure 1, more oil has been produced in this field by water flooding since its legalization in 1921 than was obtained by primary production. During the primary period, the oil was produced by gas pressure, much of the gas being blown off as an unwanted by-product, thus rapidly depressuring the field. Early attempts to repressure the field by water flooding was by "dump flooding" or allowing subsurface water to leak down the holes. During these periods no records were kept. As a result, the present condition of each area must be specifically determined before any plans can be made for development.

At present the five-spot pattern of flooding is being carried out, in which whole tracts are being laid out in the pattern of squares of approximately 330 feet on the side with the oil well usually drilled at the intersection of the diagonals of the square and the water wells drilled at the points of the squares. There are now approximately 85,000 wells in the Bradford field or an average of a little more than one well per acre. The water used in flooding is nearly always supplied from drilled wells and is mainly fresh water varying in resistivity from ten ohms to 100 or more. It is usually treated with one or more of the following chemicals: sodium carbonate, hypochlorite, Calgon, detergents and bactericides. The treatment varies according to local conditions. Water treatment is usually a separate engineering problem handled by engineering laboratories. The flood water is introduced into the intake wells by means of tubing through a packer

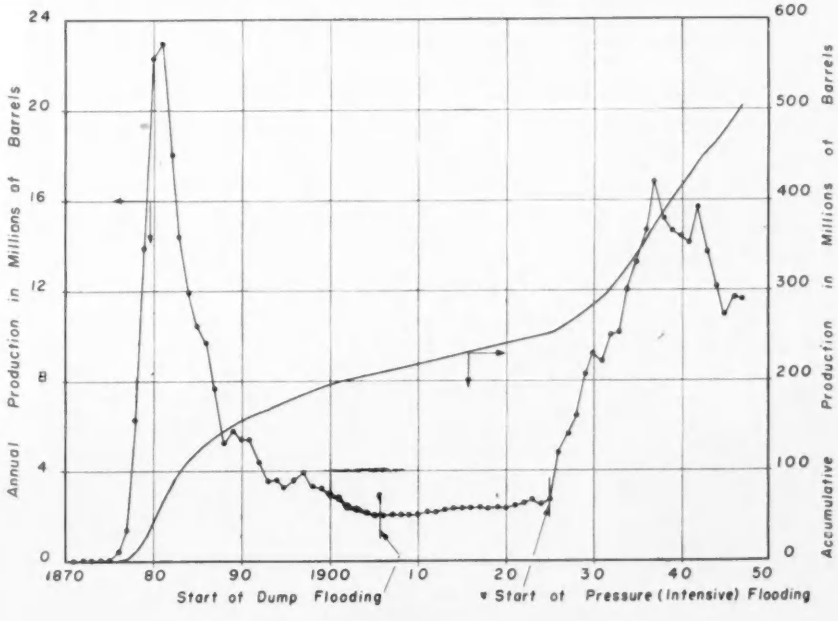

FIGURE 1

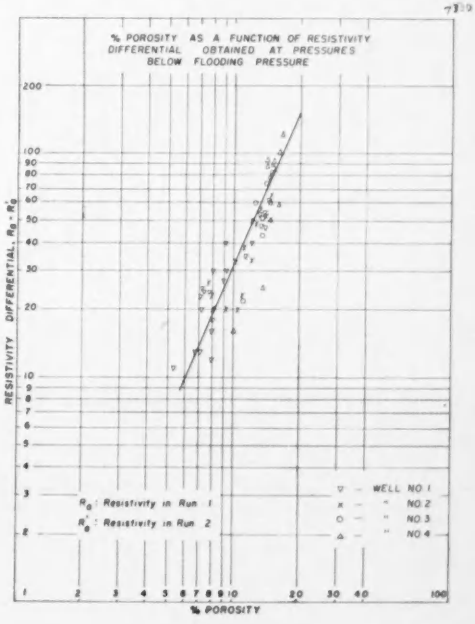
% POROSITY AS A FUNCTION OF RESISTIVITY DIFFERENTIAL OBTAINED AT PRESSURES BELOW FLOODING PRESSURE
RESISTIVITY DIFFERENTIAL, Ro - Ro'
% POROSITY
WELL NO. 1
NO. 2
NO. 3
NO. 4

FIGURE 2

which is placed just above the producing horizon. Water is injected at wellhead pressures of from 400 to 1200 pounds per square inch, varying according to the range of permeability and sand conditions encountered, as well as the average depth of the well. A rule of thumb method of determining maximum pressures is not to exceed one psi per foot of depth.

Bradford has probably engaged in a larger coring program than any other like area in the U. S. Following the introduction of cable tool coring in 1928 by Sloan and Zook, hundreds of cores of the Bradford sand have been taken. There are three consulting engineering firms engaged in coring and analyses of cores as well as several of the larger operators who carry on coring and analyses of their own.

Principal Producing Horizon

The principal producing horizon is the Third Bradford sand of the Chemung Group (Upper Devonian age) found locally from 1000 to 2000 feet. The sand is a medium fine-grained graywacke with subordinate siltstone and shale layers. Lensing and channeling on every possible scale is encountered with lenses ranging from several hundred feet in length to minute microscopic bodies smaller than the area of a thin section. The sand varies in thickness from six inches to three or four feet and is usually broken by shale laminations which reduce vertical permeability to practically zero.

As a result of their early production history, few of the sands today are in a natural state. The more permeable sands have had most of their original oil produced; the tight sands have had some of their oil produced by water flooding; and the very tight sands contain most of their original oil. The horizontal permeability of the sand may vary from less than one to several hun-

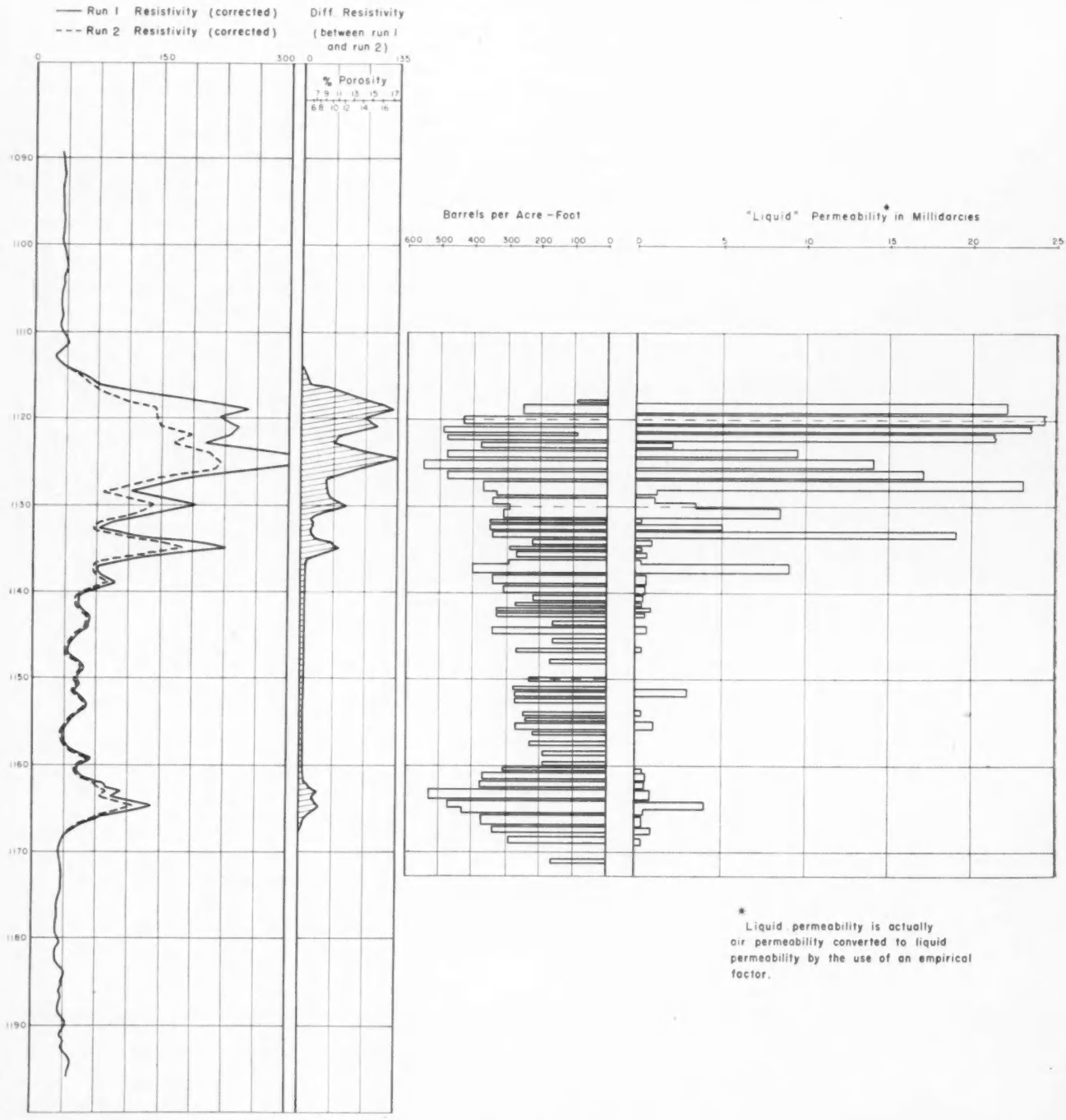

FIGURE 3

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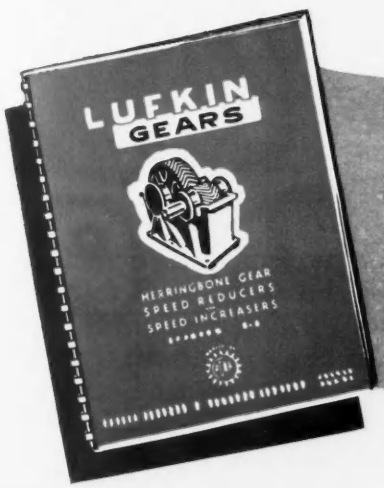

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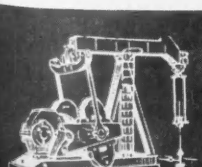
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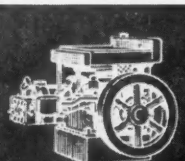
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dred millidarcys with the majority of the producing sands being less than ten millidarcys. Some of the tighter sands have oil saturations as high as 50 percent or more. These are the sands which are being profitably produced.

The water content of the sands varies as to origin, quantity and salinity. The contained water is mainly connate water in the very tight sands where flooding has been negligible, and mainly flood water in the more permeable sands, with all possible mixtures in the sands of intermediate permeability. In some cases, in the more permeable sands, water has completely surrounded the available oil, isolating it and preventing its further production by a water drive. These sands are termed "watered-out" and are often plugged off to eliminate excessive water production even though they may still contain considerable "unproducible" oil. Since all of these types of sands may be found in any one well the problem is to locate and identify them.

In addition to the variation in permeability and water content, the sands also present different depletion histories. Whereas originally the sand was probably occupied by fluids under higher pressure, now the sum of the water and oil content is equivalent to 70 or 80 percent of the pore space, the remainder being known locally as "void space," although it is probably occupied by gas or condensate under low pressure. The amount of this void space varies from layer to layer with no known trend being particularly apparent. As a result, oil saturations cannot be obtained by difference between the total pore space and the percentage occupied by water (calculated by Archie's[8] or similar formulas). The problem of obtaining oil saturations quantitatively directly from the electric log thus remains to be solved.

Problems in Bradford Electric Logging

Much varied and much accurate information is required by the producer, namely:

A. Porosities and oil saturations are needed to compute the amount of oil remaining in the sand, in particular to ascertain whether the formation is watered-out or still producible.

B. Permeabilities or water input rates are needed to determine the floodability of the sand.

C. Since most of these wells are shot before completion, the producer needs a recommendation of the size and location of the shot for each sand layer.

D. Each thin sand section is of interest since a group of these very thin sands may well determine the profit of the flood.

Electric logging has provided a qualitative answer to most of these problems; this paper records the progress attained in putting some of them on a quantitative basis.

A promising approach to the quantitative determination of permeability from the electric log was first described in an early C. Schlumberger patent (No. 2,172,625) which received a practical application in the work of C. A. Doh in Illinois on differential resistivity. The electrical logging of a well under two different hydrostatic heads gives two logs showing a difference in resistivity which seems to be correlative with permeability. It is believed that this effect is due to the invasion of fresh fluids into the pore space of the sand, altering the contained water, which in turn results in a change in the measured apparent resistivity. Extensive work along these lines was conducted in September,

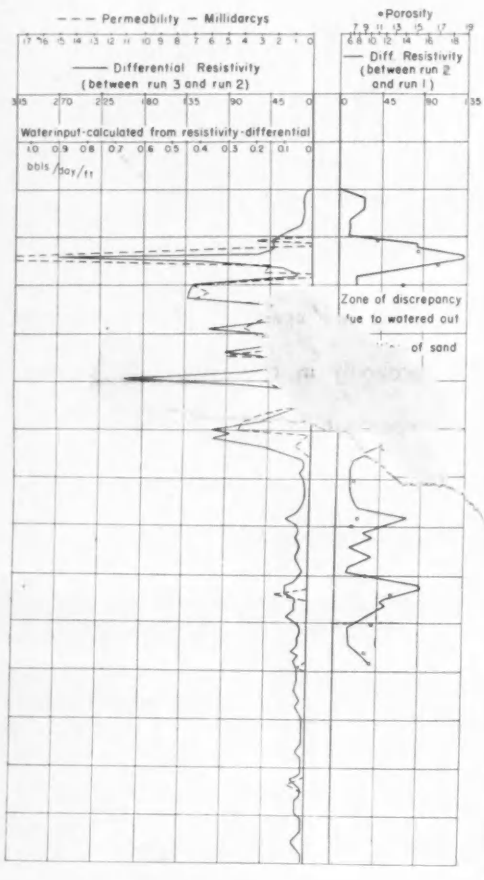

FIGURE 4

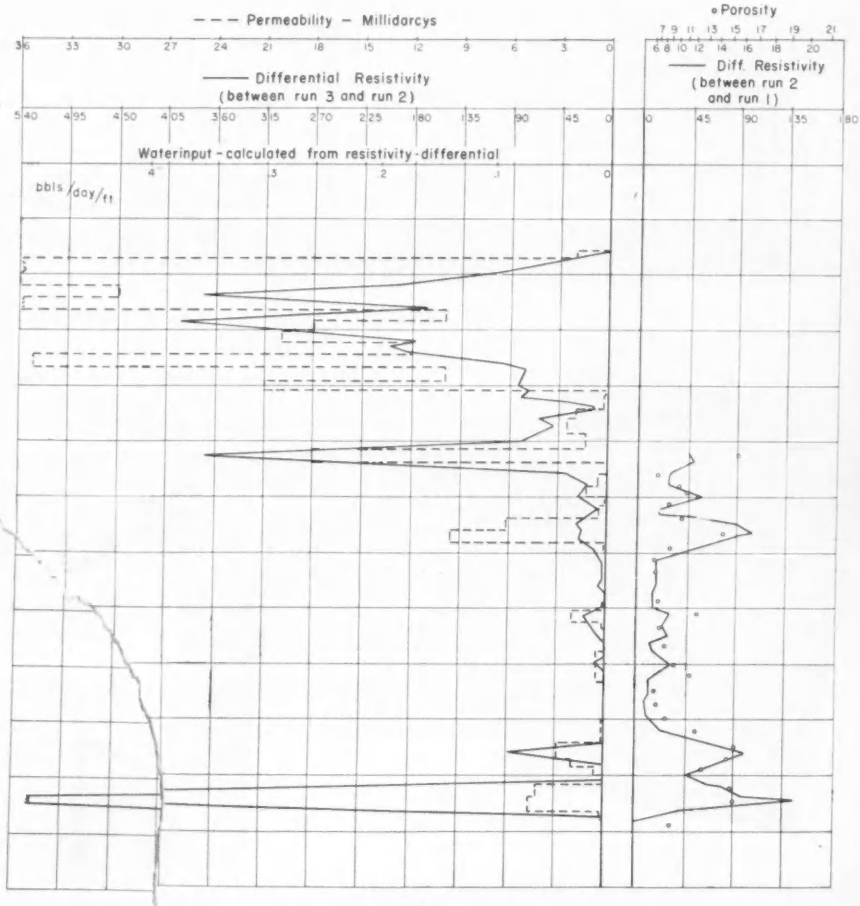

FIGURE 5

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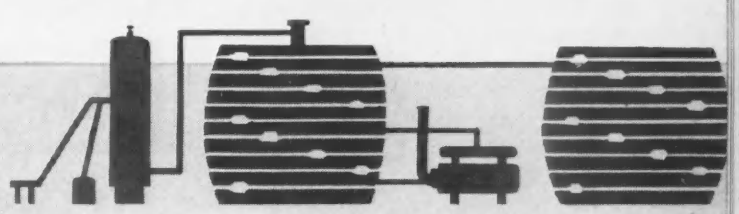

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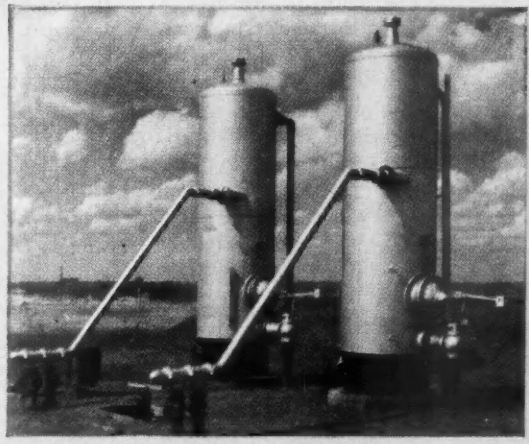

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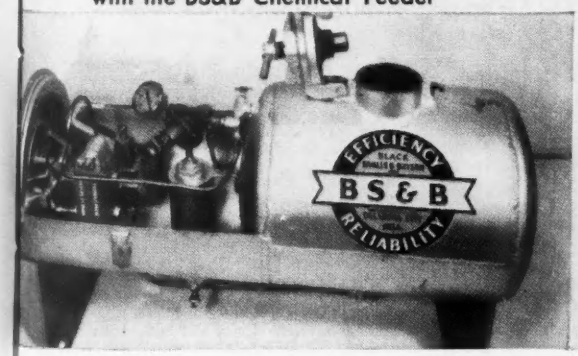

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1946, on a water-flooding project for the Pure Oil Company in the Siggens field, Cumberland County, Illinois. Shallow cable tool holes were surveyed with water just above the pay sand, then the hole was filled to the top and the resistivity curve taken again. As very little water was used during the drilling, a minimum of invasion was found on the first run. The formations being depleted, it was possible to inject a large quantity of fluid into the sand, this loss of fluid being easily traced on the second run. The differential resistivity thus obtained gave an indication of permeability to water, measured in place.

Further operations were made in both Illinois and the Appalachian region. The work in the Appalachian region immediately ran into difficulties; instead of obtaining an increase in resistivity between the first and second runs, using the technique of increasing the hydrostatic head between runs, a decrease in resistivity was noted in many instances. It was first postulated that this initial decrease in resistivity resulted from the increase in pore volume occupied by the bore hole water when the hydrostatic head was increased to a level kept below the maximum pressure prevailing in the sand just before flooding starts. (Maximum pressure will hereafter be designated as flooding pressure.) It can be assumed in these conditions that the resistivity of the sand is more affected by the increase in cross-sectional area of the current path due to the occupation by water of pore space formerly occupied by gas than by the change of salinity of the formation water. This resistivity decrease is therefore a direct function of the pore space, that is, of porosity. Increasing the hydrostatic head above the flooding pressure results in movement of fluid through the pores of the formations and to corresponding decrease of salinity of the formation water, which becomes predominant over the increase of cross-sectional area of the water channels. The resistivity of the sand therefore first decreases and later increases during the process. The resistivity increase, being proportional to the amount of water flooded through the formation, is a direct function of the relative permeability of the formations to water.

Experimental Results

The technique used in the Bradford field is based on the use of a short lateral curve (spacing of several inches) and a careful control of the amount of water in the hole. The first resistivity curve must be obtained immediately after the sand is covered with water, the amount of water used being just sufficient to cover the sand (Run 1).

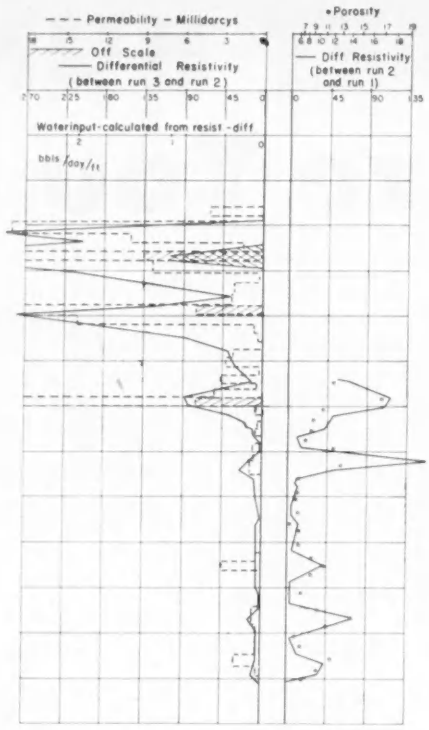

FIGURE 6

A second curve is recorded with an additional head of water selected so as not to exceed the flooding pressure and at a time interval of from one to two hours after the first run was obtained (in many cases 300 feet additional head is suitable). In fact, several intermediate runs are usually made in order to be sure to obtain the run showing the minimum resistivity (Run 2). The well is then filled with water and after a period of two to six hours an increase of resistivity is observed, as expected (Run 3). The difference between Run 3 and Run 2 gives indications of permeability. In Run 3, it is desirable to wait until several barrels of water have been forced into the sand, the time required depending upon the permeability of the sand. Future plans call for the injection of water under pressure in order to shorten the time required for a survey.

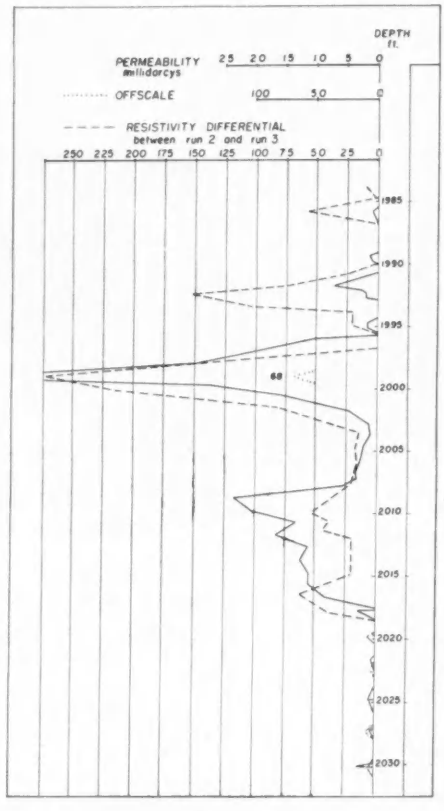

FIGURE 7

As a first approximation, the measured resistivity differential decreases were plotted against the porosities obtained from core analysis. Data obtained on four wells in widely different localities with the core analyses made by different laboratories by different methods all fell on the same straight line cure on log-log paper, shown in Figure 2. With the lateral device used, the departure curves show that for apparent resistivity/mud resistivity ratios less than 20 there is only a small difference between apparent and true resistivity differentials; hence, the former could be used with sufficient accuracy for the application of the method. For values of the ratio greater than 20 it is necessary to correct the apparent resistivities and to determine the porosity from corrected resistivity differentials. For very thin sands approximate thickness correction factors were determined empirically.

Importance of Data

It is felt that the importance of the first differential resistivity-porosity relationship, as shown in Figure 2, should be stressed. Since the wells from which these data were obtained are located some miles apart in all sections of the Bradford field, it is reasonable to assume that the curve shown is standard for the entire Bradford field. Since the core data used were obtained by different methods by different laboratories, the curve should be independent of the core analysis technique used. (The cores were chip cores on part of the wells and biscuit cores on the balance. The mercury method of porosity determination was used on the chip cores and the sand density system on the biscuit cores). Further refinement of this curve is possible but it should not be overlooked that the resultant curve cannot be more accurate than the available porosity data.

Figure 2 has been used to determine porosities on wells located in widely different portions of the Bradford field. The complete results on four of these

wells are shown in Figures 3, 4, 5 and 6. In all cases where the electric log and core report agreed on the location of sand streaks, the porosity agreement was fair except in some very tight sands. In these sands the differential resistivity gave too low porosity values. It is felt that since these sands are tight, they require a longer time interval or a higher pressure to obtain the full porosity effect. (Discrepancies are found also for sands completely watered out.)

Again as a first approximation, the differential resistivities were used to estimate the water input of the various sand layers. For this purpose the difference between Run 2 or "porosity" run and Run 3 or "full hole" run was used. The water-intake rate of the well as a whole can be calculated by measuring the amount of fluid lost between the two runs. By measuring the area under the differential resistivity curve, it is possible to distribute the water intake rates in the different lenses. Experiments to date seem to indicate that this method may be applicable (Figures 4, 5, and 6). On the three wells shown in Figures 4, 5, and 6 the correlation between individual sands looks good and the same sand streaks are taking approximately the same amount of water. These wells are located on the same lease. Comparative values of differential resistivities and permeability are shown in Figures 4, 5, 6, and 7.

ACKNOWLEDGEMENT

The author wishes to acknowledge the courtesy of the oil companies for making examples available to illustrate this paper. He also wishes to express appreciation to C. A. Doh for his advice and support in the development of the technique described and to M. Martin and June Pfister for their help in the preparation of the paper.

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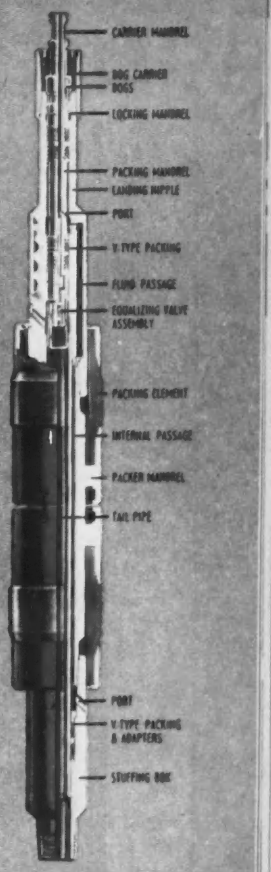

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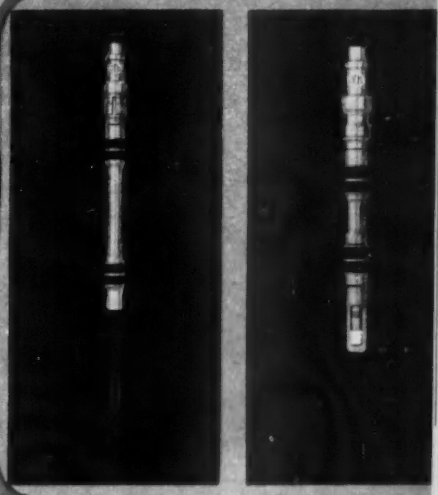

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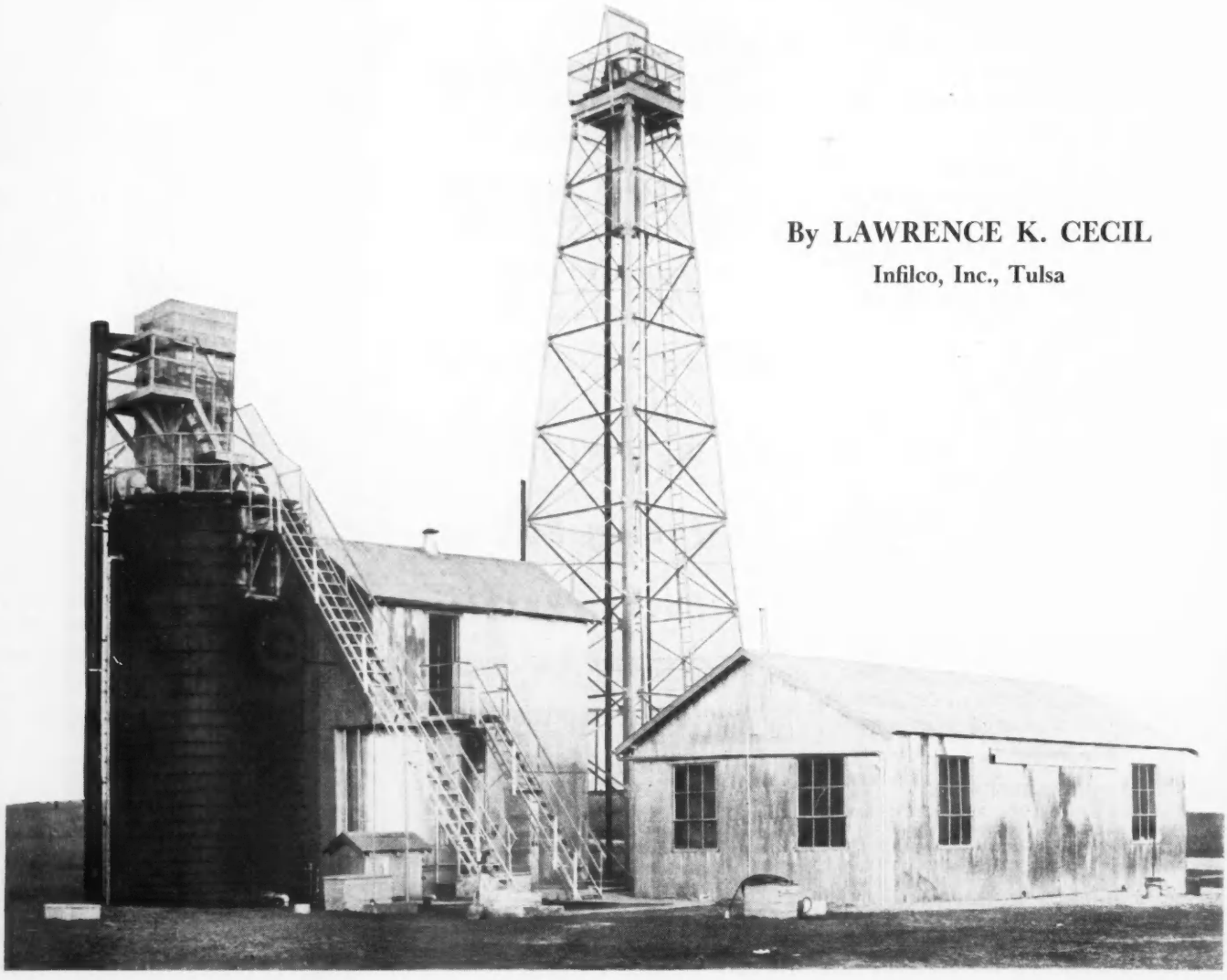
Injection Water Treating Problems

By LAWRENCE K. CECIL
Infilco, Inc., Tulsa



Brine treating plant operated by Delaware Consolidated Company, Delaware, Okla. At left is hydrogen sulfide removal unit with stabilizer and chemical feed equipment. Shown also is derrick with vacuum tower for oxygen removal. Building at right contains filter and pumps.

WATER for flooding a formation to produce oil should be of such chemical and physical quality that it will not produce changes which will decrease the capacity of the formation to accept water. The constituents that will cause plugging of the formation, and the means of removing them or minimizing their effect, are well known. They are summarized in Table 1.

The petroleum engineer should set up the requirements of water quality, leaving to the water treating engineer the problem of selecting processes and equipment to attain the desired result. It cannot be emphasized too strongly that comparison of treatment methods, physical, chemical or both, must be related to the permeability of the input formation. Adequate core studies of the formation where the proposed treatment is successful compared to similar studies where the same treatment is to be used may prevent loss of a good oil-bearing lease.

Although the susceptibility of the formation to plugging should be the basis for establishing the type of treatment and quality of the finished water, any improvement in water quality above that needed to minimize formation plugging should come under the head of insurance and the extra cost evaluated as such. This added insurance cost, when compared to the over-all cost of the project, may be good economy.

There are still some phases of preparing water for injection wells not thoroughly understood by many operators, and others on which the water engineers are still working. The following discussion is based on topics the author has found of greatest interest to men in actual operation of floods.

The well plugging effect of oil in

FILTRATION as a means for qualifying water for injection use must be carefully carried out if optimum results are to be obtained. The author discusses the use of mechanical filters for removal of treatment floc, and points out errors in operational practice which may be erroneously charged to equipment.

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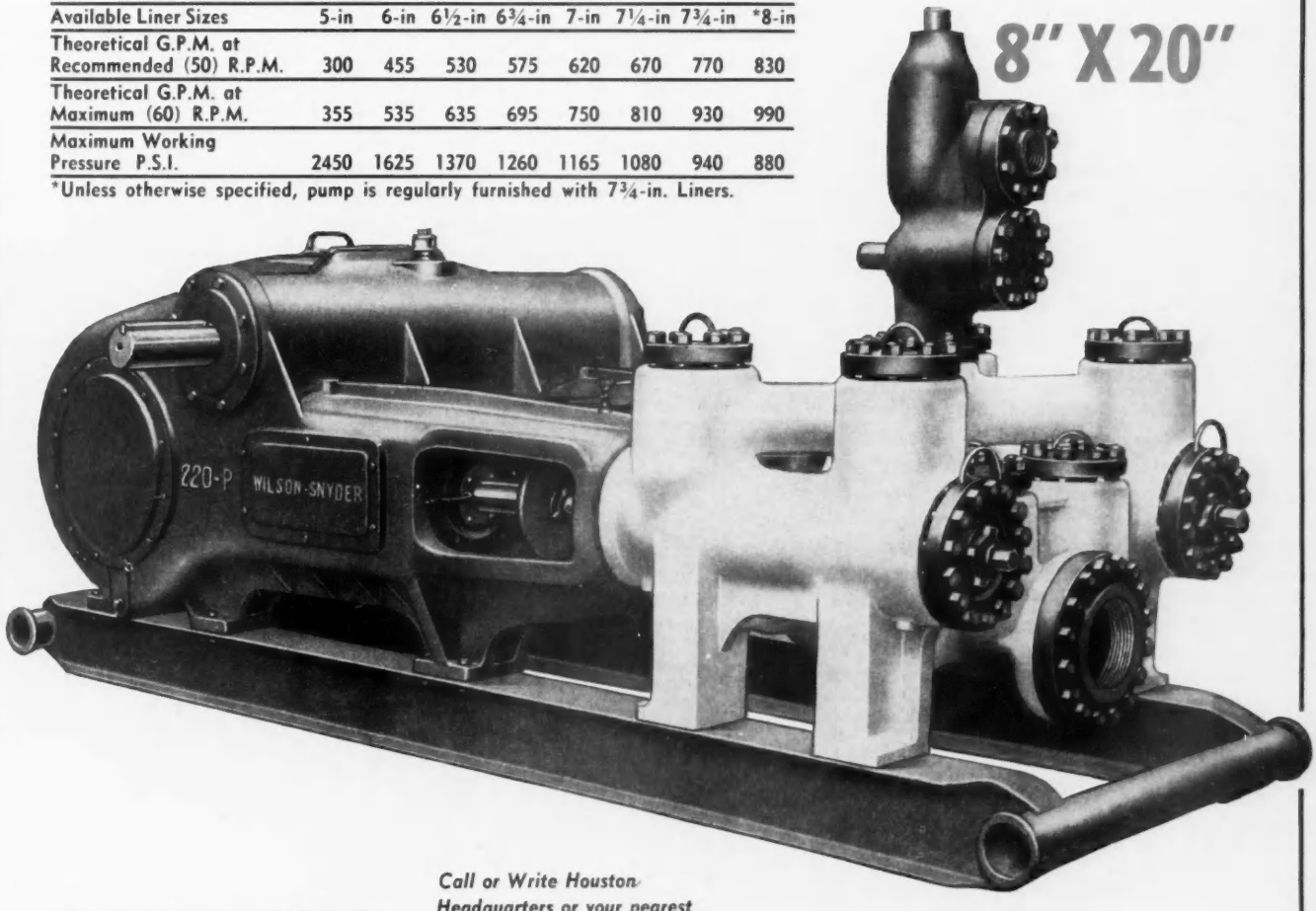
*Unless otherwise specified, pump is regularly furnished with 7¾-in. Liners.



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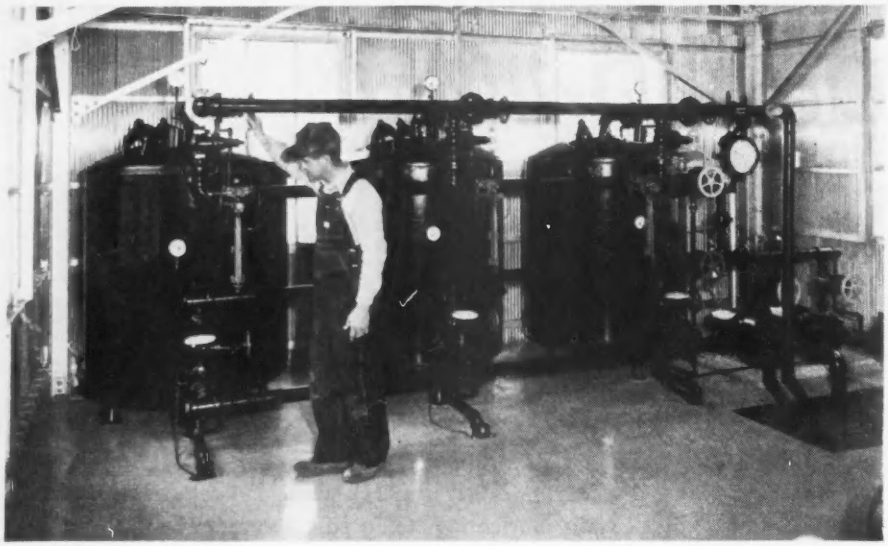


Three 4-foot pressure filters, capacity 100 gallons of water per minute, operated by Delaware at its secondary recovery water flood project at Delaware, Okla.

water is usually overlooked. Oil is readily absorbed by the gelatinous floc used for coagulation, so oil is removed incidental to clarification. There is a growing tendency to look for a chemical, the addition of which will make all waters not grossly contaminated with suspended matter, satisfactory for injection into the input well. None of the chemicals studied so far remove oil, while some actually disperse the oil, making its removal more difficult.

Polyphosphates

The peptizing effect of polyphosphates is used to delay precipitations of calcium carbonate, and to a lesser extent iron hydroxide. They must be used before the calcium carbonate or iron hydroxide is in the solid form, as the polyphosphates have little ability to redissolve and disperse solids. They are helpful in reducing meter and pipe line deposits, and to a lesser extent input well plugging.

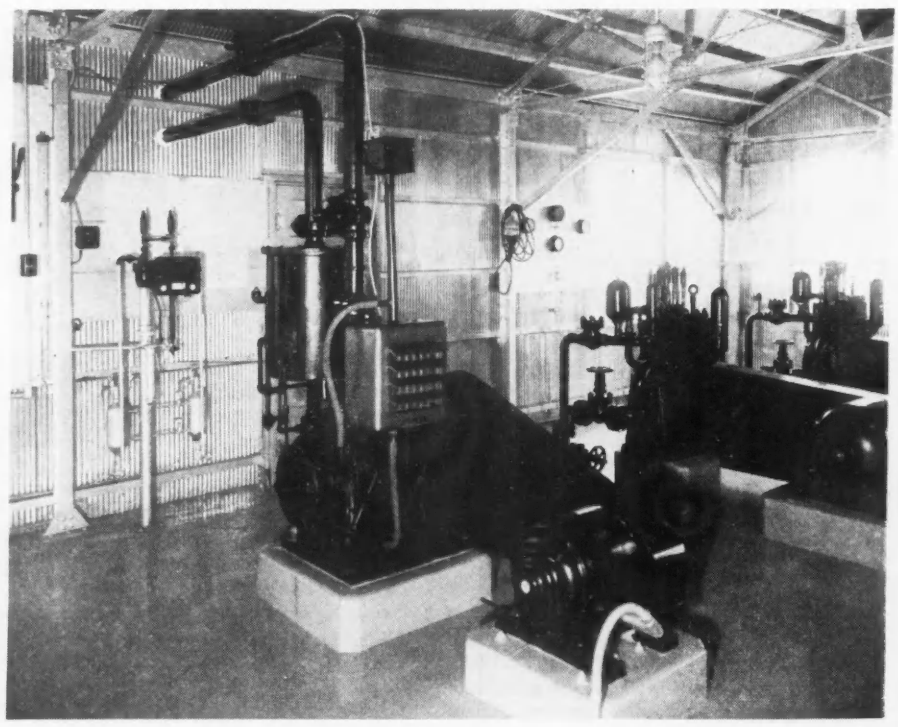
These polyphosphates revert to other forms of phosphate without peptizing power in about 24 hours, this reversion being hastened by temperature increase. The result of the use of these compounds is to transfer to the formation solids that precipitation which would have taken place in the input system. If the formation is of such a nature that this precipitation is not harmful, the use of such compounds is desirable if the cost is low enough. In determining whether the formation is able to take such precipitation without harm to eventual oil recovery, the mechanism of selective plugging from this cause should be considered. Solids precipitation will seal off the tightest sections of the pay first, diverting the water flow to more permeable sections, the cumulative effect being premature watering out of the formation. With formations of variable permeability, removal of plugging solids before injection is desirable.

The open versus closed system controversy continues. Each is adequate if properly applied. Unfortunately the open system may be so incomplete that the treated water is worse than the untreated, and the closed system often is used where it has no chance to work, or is not actually a closed system.

Open System

The open system is based on the theory of removing from the water before injection into the formation all substances that would cause plugging. These substances include suspended matter, soluble iron, excess supersaturated calcium carbonate, and bacteria. Much ferrous surface corrosion can be prevented by removal of oxygen, which is done easily in vacuum towers. Actual cost data as to the practicability of corrosion prevention by vacuum deaeration are lacking, and are needed before an economic evaluation of corrosion prevention by oxygen removal as compared to lined pipe, proper calcium carbonate equilibrium, or addition of specific chemicals, can guide a producer to selection of a corrosion control method. Oxygen is less soluble in brine that in fresh water, but costs the same for removal per unit of water, so deaeration may be less attractive in salt than in fresh water. One producer has discontinued two deaeration units recently because the benefits did not appear to justify the cost.

Two examples of improper use of open systems are: (1) Vigorous aeration for iron removal from a water containing large amounts of calcium bicarbonate without provision for control of the resultant supersaturation of calcium car-



Interior view of Delaware's pump house on secondary recovery water flooding project, Delaware, Okla., showing vacuum pump (foreground) and water injection pumps, right background.

bonate, giving a bad scaling condition. (2) Use of aluminum or iron compounds as coagulants without allowing sufficient time for formation of the gelatinous metallic hydroxide floc before the water reaches the filter bed, resulting in formation of floc particles in the filter bed or downstream from the filter.

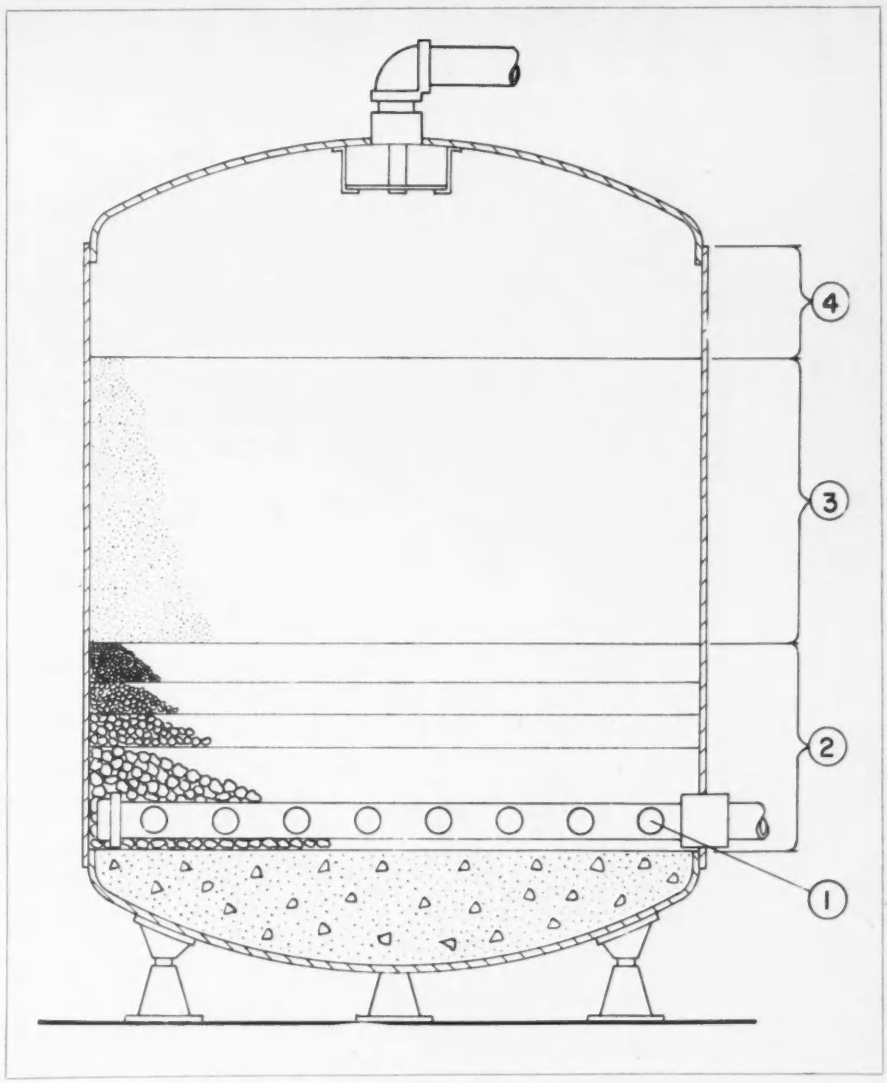
Closed System

The closed system is founded on the theory that water in a formation has reached a state of equilibrium, and if this state is not changed the water can be transferred from one formation to another without plugging effect on the second formation. The difficulty is to make the transfer without upsetting this state of equilibrium. Calcium carbonate is held in solution by excess carbon dioxide, and loss from solution of some of the carbon dioxide by reduction in pressure produces supersaturation of calcium carbonate. Introduction of air causes oxidation of iron to ferric hydroxide, one of the worst well pluggers. It is surprisingly difficult to construct and maintain a system with no danger of introducing air into the system.

Open casing heads can admit air, as has been proved in some cases by a reduction in pump corrosion after plugging the heads. A well that is pumped off to the point that there is suction at the bleeder on the downstroke draws air through the stuffing box.

A closed siphon may draw air through the gun barrel. The builder of the first siphon probably plugged the upper tees, and found that the suction created by the fall of water down the riser drained his tank. Substituting an open nipple for one plug "broke the siphon," but it also inspirated air, so the nipple was connected into the top of the gun barrel. This enables the siphon suction to draw solution gas from the oil, and if there is enough of this, no air is admitted. In many fields, however, and particularly in floods, solution gas is scant. If there is insufficient gas to hold the vacuum below ¼ ounce, the relief valve admits air, as may frequently be confirmed by ear. Failure to hear the valve rattling, however, scarcely proves that air is not entering; it is more likely to indicate a leaky deck or hatch valve.

Watershed pollution control is enforced so vigorously that salt water produced with oil should be recycled. This eliminates a disposal problem and reduces the quantity of source water required. The methods of handling return water, such as reduction to atmospheric pressure, heating or chemical addition to break emulsions, pickup of iron corrosion products, and danger of incomplete removal of oil, usually make it unsuitable for use in a closed system.



Schematic drawing of typical filter. (1) Underdrain. (2) Retaining medium. (3) Filtering medium. (4) Freeboard.

The practice of maintaining a blanket of oil on the water surface to prevent oxygen pickup is effective, but the operator should recognize and prepare against the danger of well plugging if water is drawn down so low that oil is pumped to the input well.

A proper understanding of filter operation will be very helpful to all users.

A filter, pressure or gravity, is just a strainer, and very fine particles of suspended matter must be "flocked" by proper chemicals. Particles of suspended matter larger than the voids between the filter bed grains will be retained on or near the top of the filtering surface. Smaller particles have a tendency to pass through the filter bed, although surprisingly large proportions of them adhere to the rough surface of the filter media. Silica sand has a rougher surface than anthracite coal and so is more effective in filtering a poorly coagulated water.

Anthracite coal beds do not pack and cause as much pressure loss as do sand bed, and do not have so great a tendency for growth of individual particles. These and other qualities of anthracite coal make it desirable, but many operators do not know how to decide which to use. In general, the decision can safely be based on getting sand for poorly coagulated waters and anthracite coal for those that are well coagulated.

Back-Washing

There is a common belief that coal filters can be washed at a rate much lower than is required for sand filters. It is true that anthracite has a lower effective weight in water than does a silica sand particle of the same size, and therefore a bed of coal can be suspended at a wash rate that will not lift a sand bed. Consideration of the basic principles of filter back-washing will show the hazard of accepting this belief.

A filter consists of 4 elements. (1)

The underdrain on the bottom is a pipe spreader system with drilled holes turned down or nozzles on top. Its function is to collect the filtered water and to distribute the wash water. (2) Superimposed on the underdrain are several layers of coarse filter media graduated from 2½ inch at the bottom to a size at the top small enough to prevent passage of the filtering media. (3) On this graded bed of coarse material is the actual filter bed, usually 24 inches in depth. The top few inches do most of the filtering, but the additional depth is necessary to catch particles passing the top, and to assure filtration in event of loss of part of the bed. (4) A free space above the filter bed large enough to stop turbulence is needed to protect the top of the bed. A jet of water striking directly on the filter surface will disrupt the bed, resulting in channeling with passage of unfiltered water, and inadequate backwashing.

Cleaning Filter

When a filter has accumulated its maximum safe load of suspended material it is cleaned by reversing the flow of water. This upward flow must be at a rate that will not move any of the supporting media (element 2), but will give complete suspension of the filtering media (element 3) and a thorough scouring to remove adherent floc but no loss of the filter bed, and high enough to remove and wash out all of the floc and suspended particles filtered from the water. Thus, the minimum wash rate is that needed for effective removal of floc, and this is greater than the rate that will suspend the coal filter media. The best practice, then, is to use the standard rate of 12 gallons per minute per square foot of cross sectional area.

A widespread fallacy about filter washing is that an inadequate wash rate can be compensated for by a longer time of washing. Low rate backwash for 30 or even 45 minutes is sometimes employed, but is just a waste of water, because at no time is there an upward velocity high enough to carry out the floc which settles back on the filter bed when the wash is stopped. It is a safe rule that if a filter cannot be washed clean in 6 minutes something is wrong, which should be found and corrected, rather than prolonging the wash.

In multiple filter installations there should be rate of flow gauges on each filter so the filtration rate can be divided evenly among the filters. Otherwise the cleanest filter will take the highest rate, often several times the safe design rate of 2 or 3 gallons per minute per square foot area, and the floc will be driven so deeply into the bed it will not be removed by backwashing. This filter becomes so badly fouled that its extra load is passed back to the next cleanest, and there is no indication of trouble until the last filter fails to take the overload. The best procedure then is to replace the filter beds, a cost much greater than flow gauges that could have been used to prevent the trouble.

Chlorine is effective as a sterilizing chemical, but may accentuate the corrosive tendencies of the water. Laboratory and field studies are being carried out with organic chemicals that have both bactericidal and corrosion preventive qualities. The high cost of these chemicals is retarding their acceptance, but the search for new and better compounds may accelerate this trend.

Surface Active Compounds

The use of surface active compounds that will permit more effective displacement of oil from the formation has not obtained wide acceptance although the compounds have been under consideration for perhaps 20 years. Some are effective, but the high cost in relation to results produced must be overcome before they can come into general use.

Incompatability of barium and sulfate waters is still a perplexing problem. The rate of precipitation of barium sulfate is so slow it is not practical to remove the precipitate at the surface. This slowness of reaction can be used to permit injection of a water containing one into a formation containing the other incompatible in the reservoir water. If plugging of the input well can be prevented when the flood is started (and here the peptizing value of polyphosphate shown in Table 2 is helpful) the interface of the two waters containing the incompatible substances moves steadily away from the input well into an area where the surface is so great the plugging effect may not seriously reduce the effectiveness of the flood. Channeling of input water to a producing well before barium sulfate precipitation is complete may cause serious scaling of pumping equipment. Obviously the water produced with the oil cannot be recycled with the flooding water, but must be disposed of otherwise.

There still remain many water treating problems, but fortunately there are many rugged individuals in the water flooding business who are willing to be the first to try out something new if convinced it has a good chance to succeed. In spite of the narrow profit margin that prevents spending much money gathering operating and cost data, such information is accumulating in sufficient quantity to guide the operator who reads the technical journals regularly.

About the Author

LAWRENCE K. CECIL was graduated in chemistry from the University of Illinois in 1918 and after 2 years as Oklahoma state chemist entered sales work in the field of water and sewage purification in 1924. In 1926 he joined the staff of International Filter Company (Infilco, Inc.) and is now district engineer for the Southwestern U. S. with headquarters in Tulsa.

TABLE 1

Impurity	Objection	Limits in Parts per Million	Treatment
Turbidity	Plugging	1.0	Coagulation, sedimentation, filtration
Suspended Matter	Plugging	1.0	Coagulation, sedimentation, filtration
Soluble Iron	Plugging	0.2	Aeration, pH adjustment, coagulation, sedimentation, filtration
Calcium Carbonate Supersaturation	Scaling	5–15	(1) Plate out on recirculated sludge (2) Neutralize with acid
Calcium Carbonate Undersaturation (Excess Free Carbon Dioxide)	Corrosion	0.0	(1) Aeration (2) Neutralize with lime
Insoluble Oil	Plugging	1.0	Absorption on coagulant floc, sedimentation, filtration
Hydrogen Sulfide	Corrosion	0.0	(1) Aeration (2) Oxidation to free sulfur followed by coagulation, sedimentation, filtration
Bacteria	Plugging	0.0	(1) Chlorine (2) Organic Sterilizing chemicals
Dissolved Oxygen	Corrosion	.05	Vacuum Deaeration

TABLE 2

Prevention of Barium Sulphate Precipitation by Metaphosphates

Barium	Sulfate	Metaphosphate Needed
50 ppm	100 ppm	2 to 5 ppm
100 ppm	100 ppm	10 to 20 ppm
200 ppm	100 ppm	20 to 50 ppm*

* Prevention not complete.

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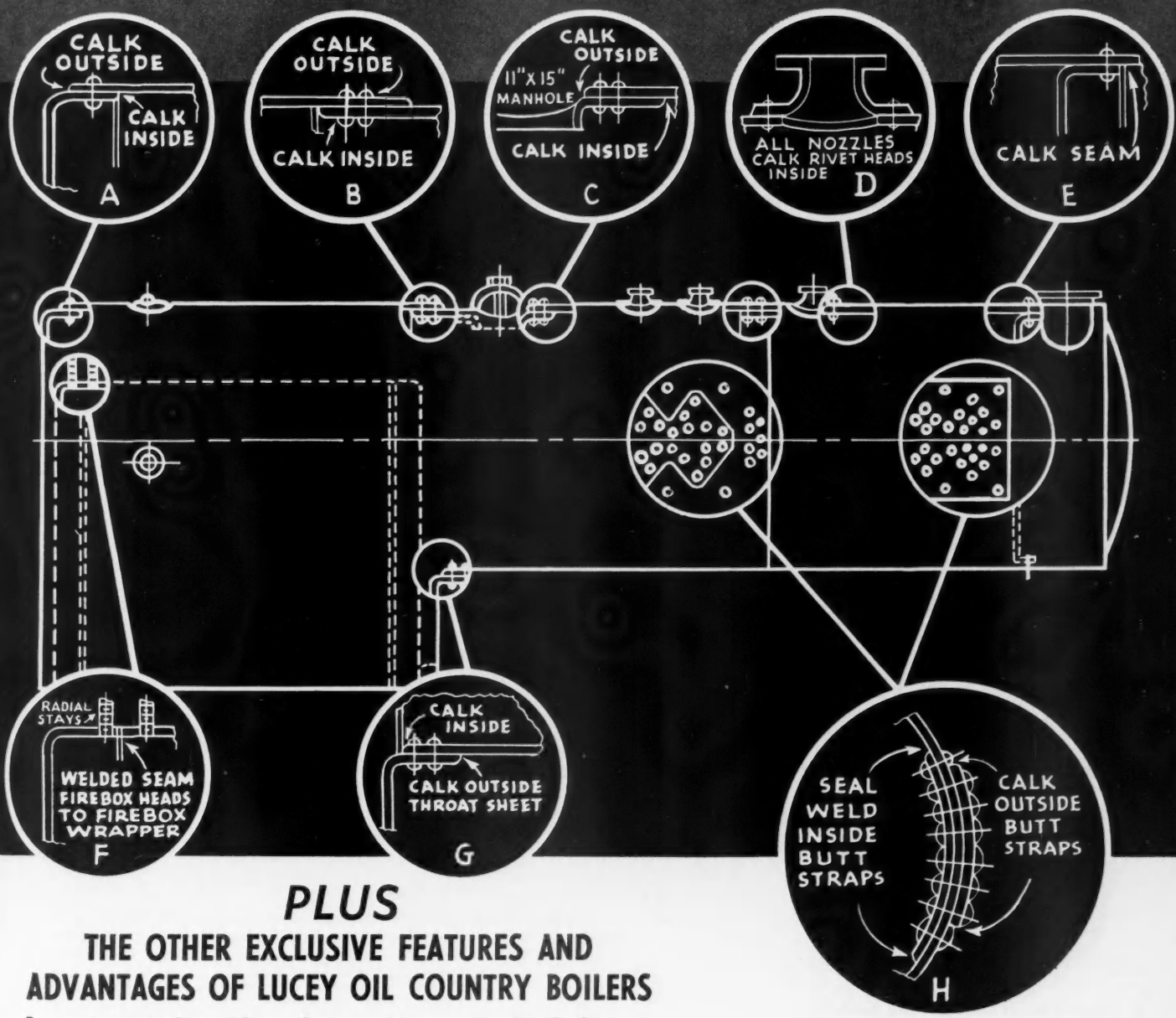

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Gas Lift
Principles and Practice
Part 2

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A PILOT controlled, pressure operated intermitting valve will first be discussed. It is constructed of 3 main assembled sections; pilot section, power bellows section and inlet valve section (Figure 2).

The pilot section controls operation of the valve. The predetermined operating valve pressure is set by tension on a spring in this section. When casing annulus pressure is raised to the opening valve pressure, the pilot opens and pressure is built up in the housing around the power bellows in the power bellows section.

Pressure on the outside of this power bellows causes the bellows to be depressed against a mechanical stop in the assembly. The power bellows is directly connected to the main inlet valve in the inlet valve section. The depressing action of the power bellows drives the inlet valve off the inlet valve seat, permitting gas to enter the tubing through the inlet port in the tube.

TABLE 2

1. Valves set at successively *lower* test block closing pressures.

Valve No.	Depth	Spacing	Surface Operating Pressure	Gas Column Weight	Test Block Closing Pressures
7	1600′	1600′	600#	25#	625#
6	2560′	960′	580#	38#	618#
5	3480′	920′	560#	49#	609#
4	4360′	880′	540#	58#	598#
3	5200′	840′	520#	69#	589#
2	6000′	800′	500#	77#	577#
1	6760′	760′	480#	83#	563#

2. *Valves set at the *same* test block closing pressures.

7	1600′	1600′	599#	26#	625#
6	2560′	960′	584#	41#	625#
5	3480′	920′	570#	55#	625#
4	4360′	880′	555#	70#	625#
3	5200′	840′	542#	83#	625#
2	6000′	800′	530#	95#	625#
1	6760′	760′	517#	108#	625#

3. *Valves set at successively *higher* test block closing pressures.

7	1600′	1600′	600#	25#	625#
6	2560′	960′	600#	40#	640#
5	3480′	920′	600#	53#	653#
4	4360′	880′	600#	65#	665#
3	5200′	840′	600#	80#	680#
2	6000′	800′	600#	92#	692#
1	6760′	760′	600#	103#	703#

* If operator prefers, the test block closing pressure of the bottom valve may be lowered slightly. Its operation will then be distinctly recorded on the surface.

When casing annulus pressure decreases to the predetermined closing valve pressure due to injection of gas into the tubing, the pilot tension spring pushes the pilot valve onto the pilot valve seat, shutting off passage of gas into the power bellows housing. Pressure in this housing bleeds off through a bleed port at the base of the power bellows. Velocity of gas passing through the inlet port forces the inlet valve onto the inlet valve seat.

To understand the method of setting valves and their operation, it is necessary to understand the operating characteristics of the valve. The predetermined closing pressure of the valve always remains the same and is the pressure by which the operating pressures in a valve string are designed. The opening pressure of the valve is variable and is a straight line function of back pressure or weight of fluid in the tubing above the valve. The less the back pressure, the higher the opening valve pressure. The greater the back pressure, the lower the opening valve pressure. This difference between the opening and closing pressure is called "spread." (Graph 1.)

With the tension spring solidly seated in the bottom of the pilot bellows guide, spring tension holds the pilot valve on the pilot valve seat (Figure 3). When the valve opens, the operating pressure is built up instantaneously in the pressure housing and remains so until the valve is closed. The closing pressure of the valve, therefore, remains constant because the valve closes with an equalized operating pressure across the valve seat.

The force required to close the valve is the spring tension required to overcome the effect of operating pressure upon the cross-sectional area of the pilot bellows. This force would be:

(1) $CP \times BA = ST$

Where:

CP=closing pressure, pounds per square inch

BA=cross sectional area of pilot bellows, square inches.

ST=spring tension.

With a valve set to close at 400 pounds and with a pilot bellows cross-sectional area of 0.30 square inch, the amount of spring tension required to close the valve would be:

$$400 \times 0.30 = 120\#$$

The valve opening pressure is the operating pressure required to overcome the spring tension. This pressure requirement is the operating pressure ef-

TABLE 3

1. Valves set at successively *lower* test block closing pressures.

VALVE No.	Depth	Spacing	Surface Operating Pressure	Gas Column Weight	Test Block Close	Spacing Calculations
6	1200′	1200′	550#	18#	568#	700# —100# +0.50
5	2280′	1080′	530#	31#	561#	568# —(1200 x 0.0224)+0.50
4	3290′	1010′	510#	43#	553#	561# —(2280 x 0.0244)+0.50
3	4220′	930′	490#	53#	543#	553# —(3290 x 0.0264)+0.50
2	5060′	840′	470#	61#	531#	543# —(4220 x 0.0284)+0.50
1	5820′	760′	450#	68#	518#	531# —(5060 x 0.0300)+0.50

2. Valves set at the *same* test block closing pressures.

6	1200′	1200′	552#	18#	570#	700# —100# +0.50
5	2280′	1080′	538#	32#	570#	570# —(1200 x 0.0224)+0.50
4	3310′	1030′	525#	45#	570#	570# —(2280 x 0.0244)+0.50
3	4270′	960′	510#	60#	570#	570# —(3310 x 0.0264)+0.50
2	5170′	900′	503#	67#	570#	570# —(4270 x 0.0284)+0.50
1	6000′	830′	495#	75#	570#	570# —(5170 x 0.0300)+0.50

3. Valves set at successively *higher* test block closing pressures.

6	1200′	1200′	550#	18#	568#	700# —100# +0.50
5	2280′	1080′	550#	33#	583#	568# —(1200 x 0.0224)+0.50
4	3330′	1050′	550#	47#	597#	583# —(2280 x 0.0244)+0.50
3	4350′	1020′	550#	62#	612#	597# —(3330 x 0.0264)+0.50
2	5430′	980′	550#	77#	627#	612# —(4350 x 0.0284)+0.50
1	6350′	920′	550#	89#	639#	627# —(5430 x 0.0304)+0.50

fective upon the cross-sectional area of the pilot bellows minus the cross-sectional area of the pilot valve seat. Pressure to open the valve, therefore, is:

(2) $(OP \times BA) - (OP \times SA) = ST$

Where:

OP=opening pressure, pounds per square inch

BA=cross sectional area of pilot bellows, square inch

SA=cross sectional area of pilot valve seat, square inch

ST=spring tension.

With a valve set to close at 400 pounds, pilot bellows cross-sectional area of 0.30 square inch, pilot valve seat area of 0.05 square inch, spring tension of 120 pounds as solved in Equation 1, the pressure to open the valve is:

$(OP \times 0.30) - (OP \times 0.05) = 120$ pounds

$(OP \times 0.25) = 120$ pounds

$$OP = \frac{120}{0.25} \text{ or } 480 \text{ pounds}$$

When back pressure, or weight of fluid in the tubing, is against the valve it is present in the power housing below the pilot section, therefore, it is effective against the cross-sectional area of the pilot valve seat. This back pressure aids in opening the pilot valve and consequently lowers the opening pressure of the valve proportionate to the amount of back pressure, in pounds per square inch, times the cross-sectional area of the pilot valve seat.

Pressure to open the valve would then be:

(3) $(OP \times BA) - (OP \times SA) + (BP \times SA) = ST$

Where:

OP=opening pressure, pounds per square inch

BA=cross sectional area of pilot bellows, square inches

SA=cross sectional area of pilot valve valve seat, square inches

BP=back pressure, pounds per square inch

ST=spring tension.

With a valve set to close at 400 pounds, pilot bellows cross-sectional area of 0.30 square inch, pilot valve seat area of 0.05 square inch, spring tension of 120 pounds as solved in Equation 1 and 200 pounds back pressure against the valve, pressure to open the valve would then be:

$(OP \times 0.30) - (OP \times 0.05) + (200 \times 0.05) = 120$ pounds

$(OP \times 0.25) + 10 = 120$ pounds

$$OP = \frac{110}{0.25} \text{ or } 440 \text{ pounds}$$

There are three distinct methods of designing the operating pressure of a valve string. All are proven methods and each has its advantages and disadvantages. Local surface or individual well conditions and the operator's preference are factors governing the method used for any particular installation:

These methods are:

1. All valves set at successively lower test block closing pressures as they are placed lower in the string.
2. All valves set at the same test block closing pressure.
3. All valves set at successively higher test block closing pressures as they are placed lower in the string to give the same surface operating pressure.

The test block closing pressure of a valve, referred to above, is the actual closing pressure of a valve in a test block. The surface operating pressure is the test block closing pressure minus the weight of the gas column from the surface to the depth of the valve.

To illustrate the 3 different methods of setting valves, a theoretical setting with the same number of valves, valve depths and spacings, would compare as shown in Table 2.

All valves set at successively lower test block closing pressures as they are placed lower in the string. This is the oldest method used for designing operating valve pressures. It usually places the highest test block closing pressured valve in the top of the string and the lowest test block closing pressured valve in the bottom of the string. With this type setting, a predetermined surface operating pressure for each valve is selected. Weight of the gas column from the surface to the depth of each valve in the string is added to the selected surface operating pressure of each valve. The surface operating pressure plus the weight of the gas column is the test block closing pressure of each valve.

This type setting has a distinct ad-

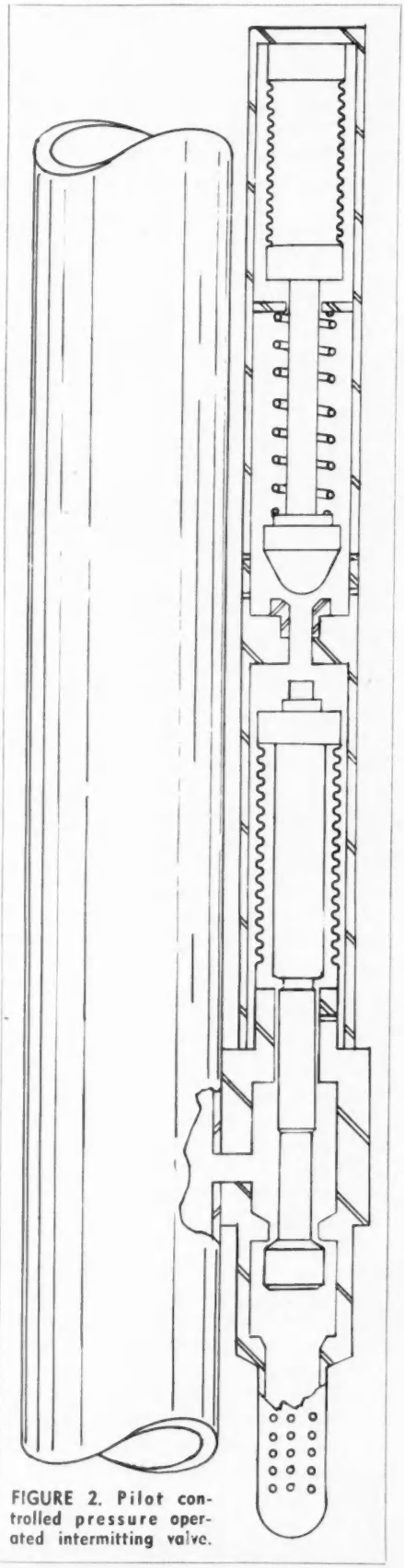


FIGURE 2. Pilot controlled pressure operated intermitting valve.

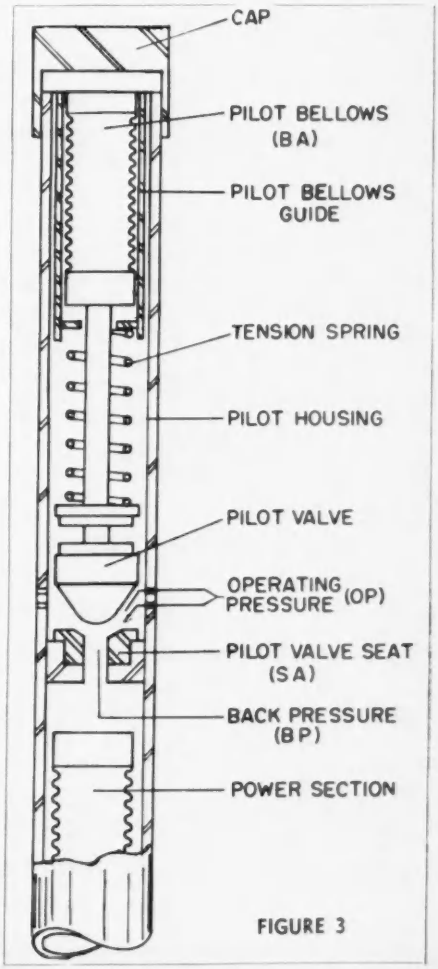


FIGURE 3

vantage because the operating valve in the string can be determined from the surface operating pressure. A disadvantage of this type setting is loss of operating pressure as the working level of the well is successively lowered. It is desirable that the highest possible operating pressure be utilized as the depth of operation increases. In deep wells, a pressure loss in each valve spacing results in the bottom valve operating pressure becoming insufficient to give satisfactory operation. In comparatively shallow depth wells and with ample maximum available surface operating pressure, this type setting is satisfactory.

Control of this type setting is usually by a surface time cycle controller.

All valves set at the same test block closing pressure. Decided improvements in methods of designing operating valve pressures have been developed and proven in operation. One such method is that all valves are set at the same test block closing pressure. This is possible by using a valve design sensitive to the amount of back pressure, or weight of fluid in the tubing, above the point of the valve in the string.

The lowest valve exposed to casing annulus pressure will have the greatest amount of back pressure against it. The opening pressure of this valve, a straight line function of the amount of back pressure against it, (Graph 1) will be lower than any valve above it. This assures the lowest possible working level according to individual well characteristics and operating pressure.

The surface recorded pressure will be the test block closing valve pressure minus the weight of the gas column from the surface to the point of the valve in the string. This surface recorded pressure will decrease as the depth of working level increases. The weight of the gas column need not be calculated in the valve setting except for the surface recorded pressure data.

This type setting places a higher operating pressure in the bottom of the hole than the successively lower test block closing pressure method. This higher operating pressure is desirable for efficient operation.

Control of this type setting is usually by a surface time cycle controller.

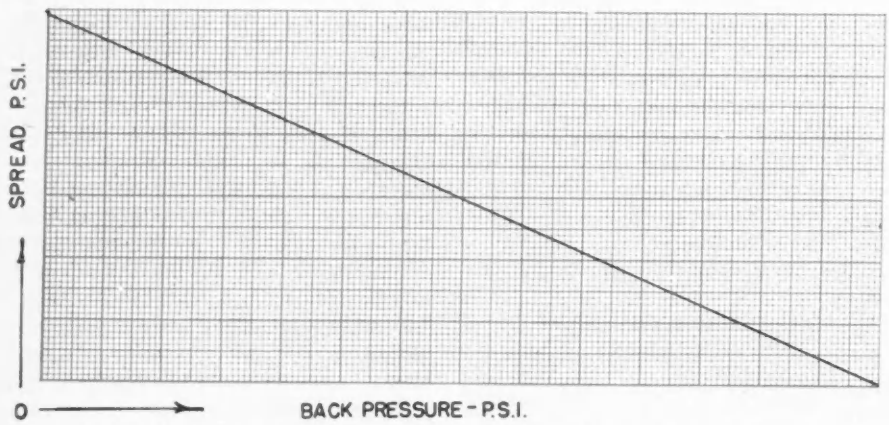
All valves set at successively higher test block closing pressures as they are placed lower in the string to give the same surface operating pressure. A more recently designed method of setting valve pressures has been developed and proven in operation. By this method, the lowest operating pressured valve is placed in the top of the hole and the highest operating pressured valve is placed in the bottom of the hole. The valves are set to operate at successively higher test block closing pressures as they are placed lower in the string.

With this type setting, the surface operating pressure remains the same regardless of the valve operating depth. The available operating pressure in the bottom of the hole is the surface operating pressure plus the weight of the gas column in the casing annulus. A valve designed to utilize this increased available pressure makes it possible.

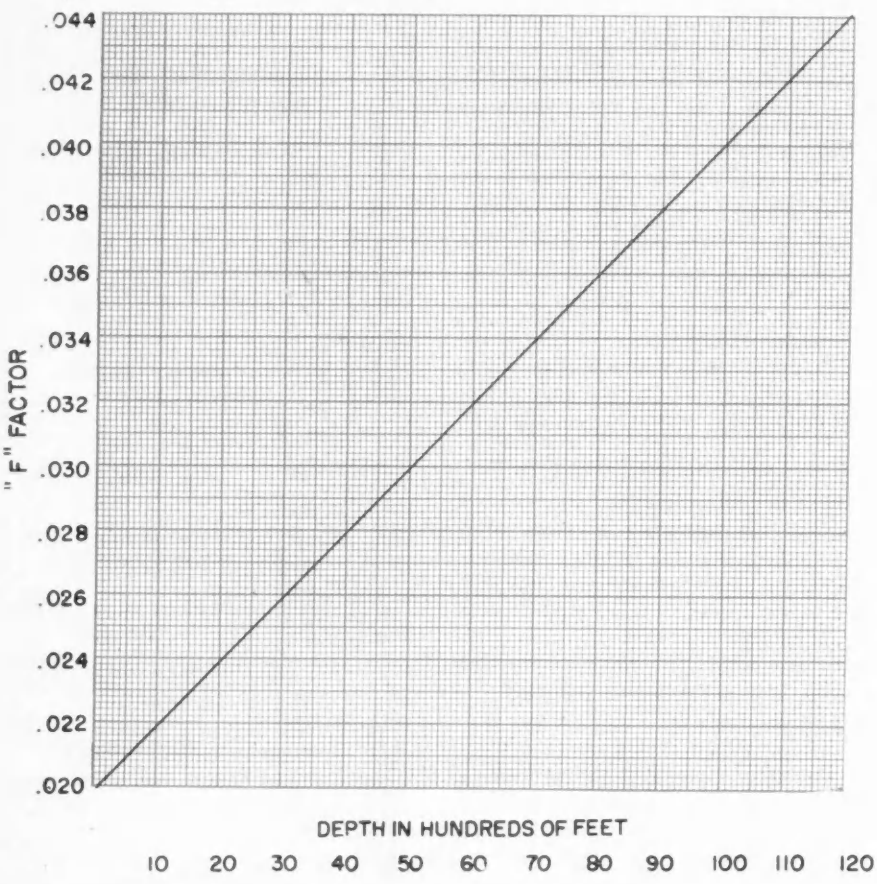
Basically, operation of this type installation is the same as when all valves are set at the same test block closing pressure. The lowest valve exposed to casing annulus pressure will have the greatest amount of back pressure against it, therefore, it will have a lower opening pressure than any valve above it. With the surface operating pressure remaining the same, regardless of depth of operation, it is impossible to determine the operating valve by the recorded surface operating pressure.

Setting of the test block closing valve pressures is computed by adding the weight of the gas column from the surface to the point of the valve in the string to the surface operating pressure.

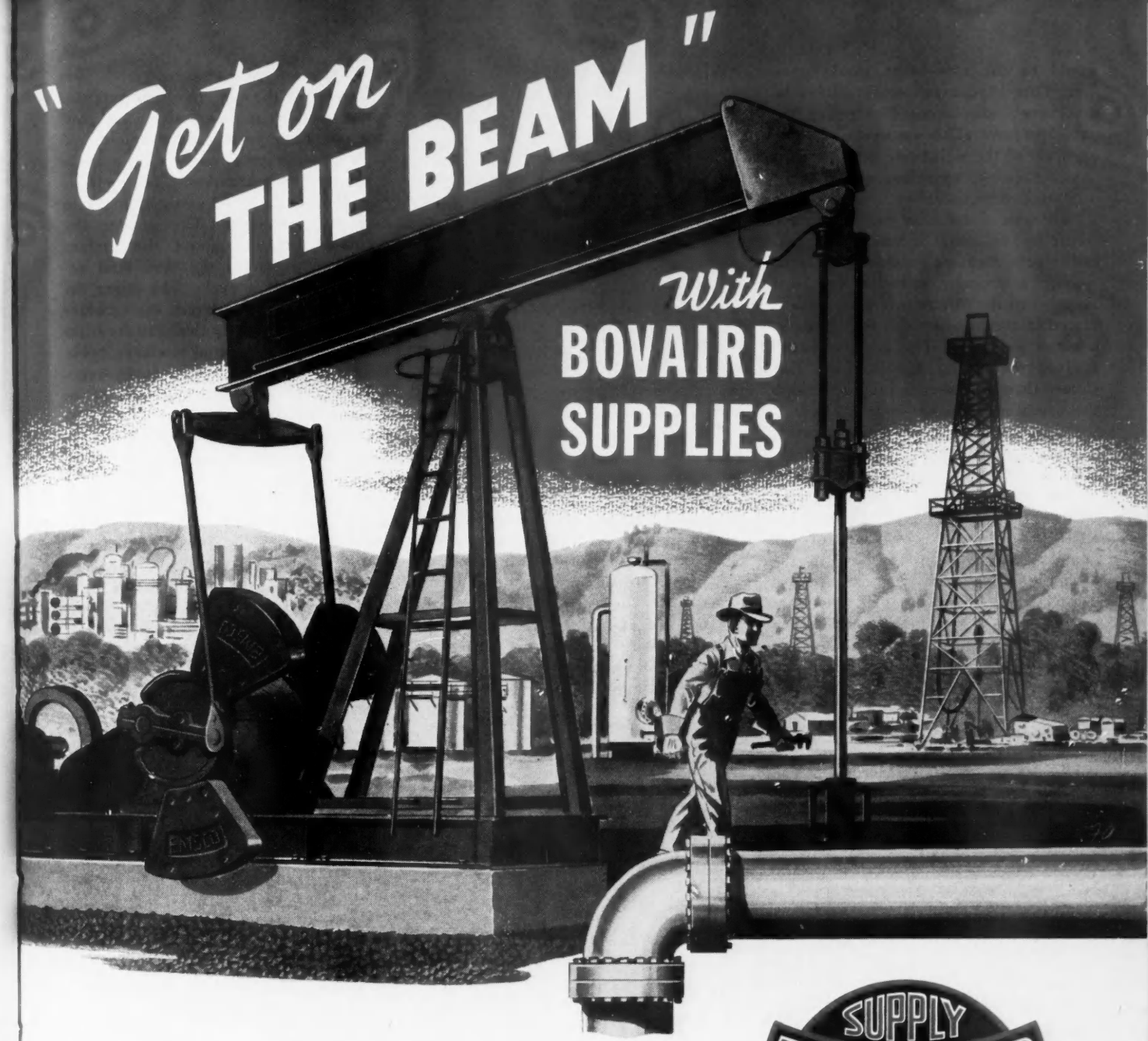
With valves set in this manner, it is evident that any raise in casing annulus pressure affects the opening pressure of each valve in the string identically. Each valve in the string would be primed to open at the increased surface operating pressure. Any valve in the string having the required back pressure against it



GRAPH 1. Illustrating "spread" between opening and closing pressure of valve.



GRAPH 2. Intermitting valve spacing factor for use with Equation 6.



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would be the valve that would open first. This, of course, would always be the lowest valve exposed to casing annulus pressure. This assures the working level of the well being at the lowest possible point according to pressure used and well conditions.

This type installation can be surface controlled by either a time cycle controller or a pressure reducing regulator.

With a pressure reducing regulator installed in the injection line, a choke is placed in the line between the regulator and the well head. This choke is sized to feed the casing annulus at a rate slower than the passage of gas through the operating valve when it is open.

Let us assume a surface operating pressure of 600 pounds is being used. This is the surface operating pressure of each valve in the string. A pressure reducing regulator is set to hold a constant casing annulus pressure of 630 pounds. This pressure is held in the casing annulus until the well feed-in creates back pressure above a valve that will open at a 30 pound spread. When this condition occurs, the valve opens automatically, injecting gas under the fluid column and delivering to surface.

When the valve opens and injects gas into the tubing, the casing annulus pressure drops. The pressure reducing regulator opens, due to the reduced annulus pressure, feeding the annulus through the choke at a rate less than the gas passage of the valve. The annulus pressure continues to drop to the surface operating pressure of 600 pounds. The operating valve closes at this 600 pounds surface operating pressure. The regulator continues to feed the annulus until it is again raised to 630 pounds at which point it closes and the installation is primed, so to speak, until the back pressure condition exists inside the tubing to start another cycle.

The volume of gas in the casing annulus from the controlled regulator pressure to the surface operating pressure is the volume injected into the tubing during each cycle. The amount of fluid in the tubing to create the required back pressure is the exact amount that will be in the tubing when each cycle is started. These two factors remain constant for operation after control adjustment. Since these factors do remain constant, the amount of fluid produced and the injection of gas-fluid ratio for each cycle will be the same.

By varying the amount of pressure the casing annulus is raised above the surface operating pressure, the amount of back pressure required to start a cycle is changed proportionately. The installation, therefore, can be easily adjusted to maximum efficiency. The greater the regulated pressure above the surface operating pressure, the less fluid required to start a cycle. The lower the regulated pressure over the surface operating pressure, the greater the amount of fluid required to start a cycle. Controlling these two factors, by regulation, permits a gas-fluid ratio to be set, maintained and controlled. This method is applicable to the smaller capacity wells of approximately 100 to 150 barrels total fluid per day.

In spacing intermitting valves, the top valve is spaced from the surface according to the static fluid level in the well and available surface operating pressure.

Where the static fluid level is at or near the surface, the spacing of the top valve from the surface is as follows:

$$(4) \qquad S = \frac{P - D}{G}$$

Where:

S = distance in feet to top valve from surface

P = available surface operating pressure, pounds per square inch

D = desired differential across valve when it is exposed to annulus gas pressure, pounds per square inch, usually 100 pounds

G = static fluid gradient, psi per foot of height.

For example: with 600 pounds available surface operating pressure and a fluid gradient of 0.40 psi, the top valve would be spaced:

$S = \frac{600 - 100}{0.40}$ or 1250′ from the surface.

Where the static fluid level is at such depth that available operating pressure is less than that required to balance a column of fluid equal in height the distance from the surface to the static fluid level, the ratio of the annulus and tubing areas must be taken into consideration. Under these conditions, the equation for spacing the top valve from the surface would be:

$$(5) \quad S = SFL + K\frac{P - D}{G \times (1 + R)}$$

Where:

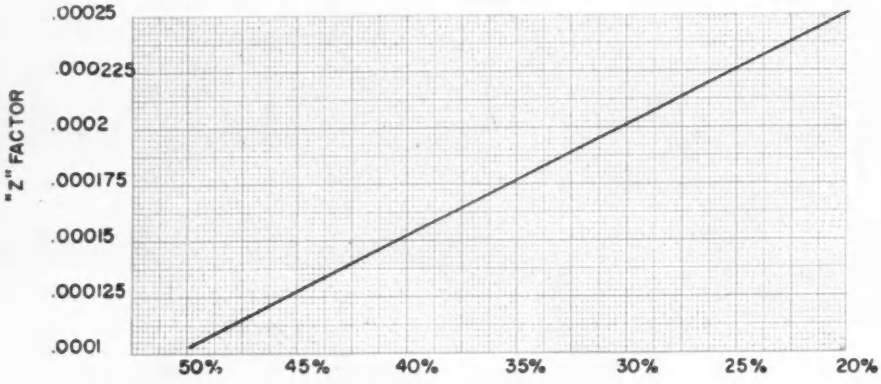
S = distance in feet of top valve from surface

SFL = static fluid level in feet from surface

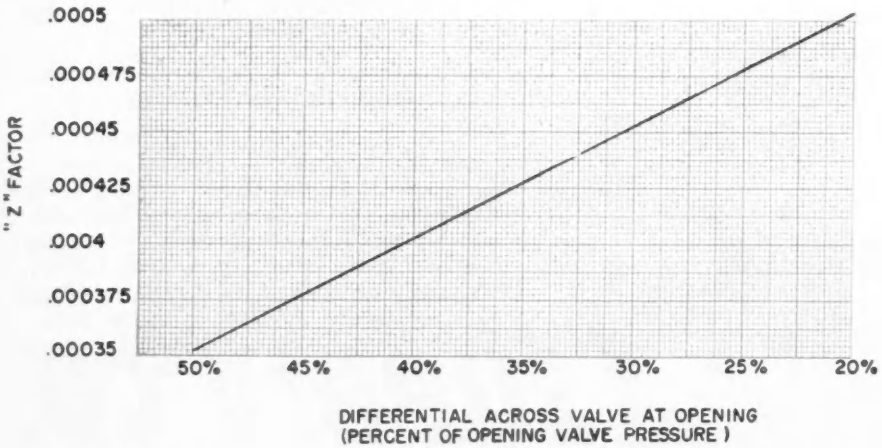
P = available surface operating pressure, psi.

D = desired differential across valve when it is exposed to annulus gas pressure, psi, usually 100

G = static fluid gradient, psi, per foot of height



GRAPH 3. "Z" Factor for computing theoretical size of heads, in barrels, for 2-inch tubing. Use with Equation 7.



GRAPH 4. "Z" Factor for computing theoretical size of heads, in barrels, for 2½-inch tubing. Use with Equation 7.

R=ratio of casing annulus area to tubing area.

For example: with 600 pounds available surface operating pressure, a static fluid level 2000 feet from the surface, fluid gradient of 0.40 psi, well equipped with 5½ inch O.D. 14-pound casing and 2-inch EUE tubing, (ratio 4.9 to 1), top valve in the string would be spaced.

$$S = 2000 + \frac{600 - 100}{0.40 \times (1 + 4.9)}$$

or 2212 feet from the surface.

Although the above equation may be used in positioning the top valve, it is good practice to position this valve at the static fluid level.

Spacing of the valves under the top valve are computed by the following:

(6) $$S = \frac{TBP - (DVA \times F)}{SFG}$$

Where:

S=Spacing in feet of valve from the valve above

TBP=test block closing pressure of valve above, psi

DVA=depth in feet of the valve above from the surface

F=factor (Graph 2)

SFG=static fluid gradient, psi, per foot of height. (If unknown, use 0.50).

Note: If the surface back pressure is greater than 35 psi, the entire back pressure should be subtracted from the factor TBP before the spacing is computed, otherwise, disregard the surface back pressure.

For example: with a surface operating pressure of 700 pounds, fluid at or near the surface, an estimated static fluid gradient of 0.50, the spacings and valve pressures under the 3 different methods of setting valves would be computed as shown in Table 2.

When valve spacings have been computed, good judgment should be used in adjusting the spacings to position the bottom valve at the desired depth. If the computed spacings place the bottom valve above the desired depth, it is rarely good judgment to extend the upper valve spacings to position the bottom valve correctly. It is usually better to add another valve and absorb the added spacing in spacing lower valves.

Theoretical size of heads in barrels, for intermitting operations, may be computed by the following equation:

(7) $$H = \frac{P - D \times C - (L \times D)}{G}$$

Where:

H=theoretical size of head in barrels delivered to the surface

P=pressure at operating valve, psi

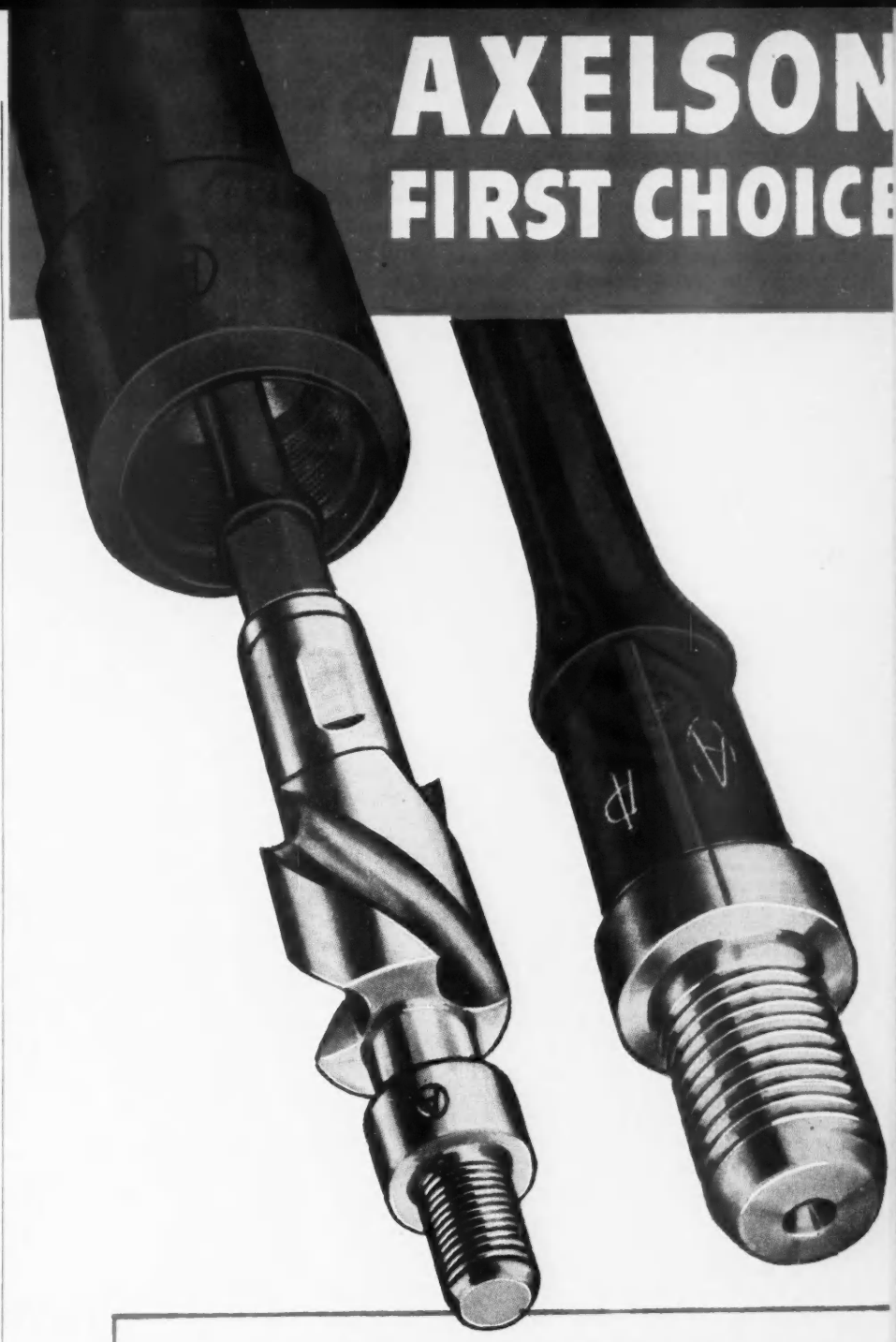
D=differential across the valve when opened, psi

G=gradient of fluid column, psi, per foot of height

C=Tubing capacity in barrels per foot

(2-inch tubing—0.00387)

(2½-inch tubing—0.00579)



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L=factor for rate of loss in barrels per minute per 1000 feet of travel
d=depth of operating valve in feet.

For example: with a 550 pounds operating valve, 2-inch tubing, depth of 6000 feet, fluid column gradient of 0.40 psi and an estimated differential of 30 per cent of the valve operating pressure when the valve is opened, the equation would read:

$$H=\frac{550-165\times0.00387-(0.0002\times6000)}{0.40}$$

or 2.52 barrels.

The quantity of gas required per head, for intermitting operations, may be computed by the following equation.

(8) $$QH=\frac{VT\,(PC)}{BP}$$

Where:

QH=cubic feet of gas, at base pressure, required per head
VT=tubing volume, in cubic feet, from surface to operating valve
PC=pressure exerted by fluid column, psi
BP=base pressure of gas.

For example: continuing the conditions under Equation 7, a theoretical head of 2.52 barrels, 2-inch tubing, depth of 6000 feet, fluid column gradient of 0.40 psi and an assumed base pressure of 14.5 percent.

The cubic foot volume in the 2-inch tubing would be 0.387×5.61×60 or 130.20 cubic feet. The 2.52 barrels of fluid is equal to a height in the 2-inch tubing of 2.52×258.65 or 642 feet. This column of fluid at a gradient of 0.40 exerts a pressure of 256.8 psi. The equation for QH would then be:

$$QH=\frac{130.20\times256.8}{14.5}$$

or 2306 cubic feet per head.

The quantity of gas required per barrel would be 2306 divided by 2.52 or 915 cubic feet.

The amount of casing pressure drawdown required to inject a certain amount of gas from the casing annulus into the tubing may be computed by the following equation:

(9) $$CD=\frac{QH}{VA}\times B$$

Where:

CD = casing pressure draw down required per head, psi
QH = quantity of gas required per head, cubic feet
VA = cubic feet of volume in casing annulus from surface to operating valve
B = base pressure of gas.

For example: continuing the condition under Equation 8, where 2306 cubic feet of gas per head was required, 2-inch tubing, depth of 6000 feet and an assumed base pressure of 14.5 pounds; if the well were equipped with 5½-inch, 14-pound casing, the volume in the casing annulus from the surface to the operating valve would be 1.89×5.61×60 or 636 cubic feet. The equation:

$$CD=\frac{2306}{636}\times14.5 \text{ or } 52 \text{ pounds.}$$

There are several equations for calculating the operating efficiency of an intermitting installation. Some of these will provide different conclusions due to the principle on which they are based. It is suggested that a reasonable equation be selected and used consistently for comparative purposes.

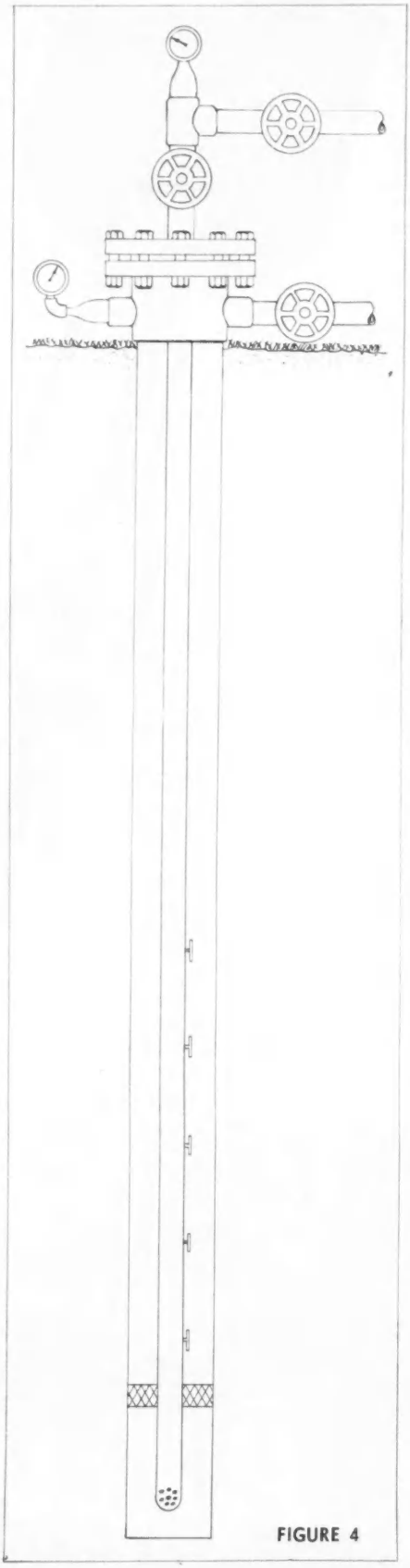


FIGURE 4

The following method is suggested for calculating the operating volumetric efficiency of an installation.

The effective lift of an installation is from the point of gas injection to the point of fluid discharge. The entire fluid head per cycle must be delivered out of the eductor tube at the point of discharge before the delivery is completed.

The volume of gas in the eductor tube at the pressure required to balance the fluid head represents the minimum amount of gas required to lift the head of fluid. The ratio of this volume to the actual volume of gas used represents volumetric efficiency of the installation.

For example, let us assume:

Lift	5,000 feet
Total cycles per day	48
Total fluid per day	96 barrels
Fluid gradient	0.40
Barrels per cycle	2
Tubing size	2 inches
Actual gas-fluid ratio	1.8 mcf

Two barrels of fluid in 2-inch tubing occupy a height of 2×258.65 feet or 517.3 feet. This column of fluid at a gradient of 0.40 exerts a pressure of 0.40×517.3 or 206.92 psi. This 206.92 psi at a base pressure of 14.5 pounds, is equal to 206.92+14.5 or 14.27 pressure atmospheres. The 5000 feet of 2-inch tubing contains a volume of 0.387×5.61×50 or 108.5 cubic feet. This tubing volume at 14.27 atmospheres is equal to 108.5×14.27 or 1548 cubic feet. This is the minimum volume required per cycle of two barrels fluid or a minimum volume of 774 cubic feet per barrel. If the actual gas-fluid ratio is 1.8 mcf, the installation efficiency is

$$\frac{0.774}{1.8} \text{ or } 43 \text{ percent.}$$

The closed installation (Figure 4) is perhaps the most common type of installation in gas lift operations because of the wide range of individual well conditions it will handle. A packer is run and set in the casing, usually immediately below the bottom valve. A perforated nipple is run below the packer and a standing valve, if used, is run between the packer and perforation.

Valve operation by intermitting cycles frees the casing annulus of fluid and it then becomes a gas volume chamber. With a standing valve in the tubing string, the operating pressure is prevented from reaching the face of the producing formation. This permits fluid to feed into the well bore at a maximum differential between operating cycles.

Wells of comparatively low fluid productivity and wells producing the maximum capacity of the intermitting valves can be handled with this installation.

How to do it! PRODUCTION HINTS

$10 is paid for each illustrated acceptable contribution. Mail to The Editor, WORLD OIL, P. O. Box 2608, Houston 1, Texas

HOW TO—Utilize Flowing Well Gas

It is often necessary to have near an oil well a gas supply to run a chemical pump, heat a dog house or light a warning light on offshore locations such as the one shown. Here the warning light is off to the left and connects to one wing of the christmas tree through copper tubing.

A tee is turned upwards on the flowing wing of the tree and a valve installed. A 4-foot riser is then screwed into the top of the valve and swaged down to ¼-inch at the top. A pressure reducing regulator is then screwed on the quarter-inch which reduces the pressure to ounces, for use on the warning light. As the gas rises several feet, it is scrubbed free of oil and is suitable for use as fuel.

A pot with a float inside is installed on the line (shown at the left) so that if any liquid kicks over, the float will shut off the gas before any damage is done. The copper tubing then runs to the warning light.

HOW TO—Build Tank for Gas-Lift

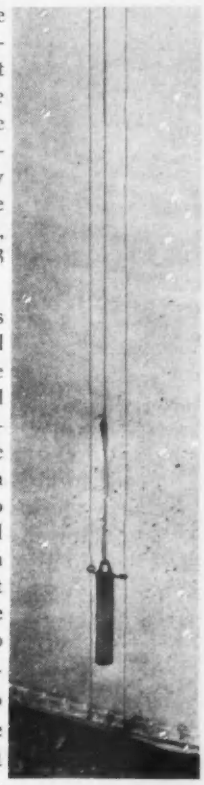
When wells on a small tract are placed on gas-lift using intermittent flow valves, the discharge pressure of the compressor fluctuates over a wide range, depending on whether the intermitters are on or off. This interruption will cause the gas to be popping into the air or back into the intake when the wells are not taking gas, and will result in very low pressures when two or more intermitters kick off at the same time.

One operator uses several joints of heavy-duty 6-inch pipe to maintain a steady pressure on the discharge. Using 5 joints of pipe in 6 sections welded together, U-bends are welded on each end to make a continuous coil of pipe. At either end of the first section, the connections are made to the casings of the gas-lift wells, and nipples across the coils near the compressor connect the coils together.

While the intermitters are shut off, the compressor continues to build up pressure inside the coils, and there is a steady feed to the valves once the intermitter opens, thus causing more efficient use of the gas.

HOW TO—Make Simple Device For Gauging Tank

On water tanks where accurate gauges are not necessary, yet a constant watch must be made to maintain the proper level, a simple gauging unit may be made by the use of a float, weight, pulley wheel and 3 pieces of wire.

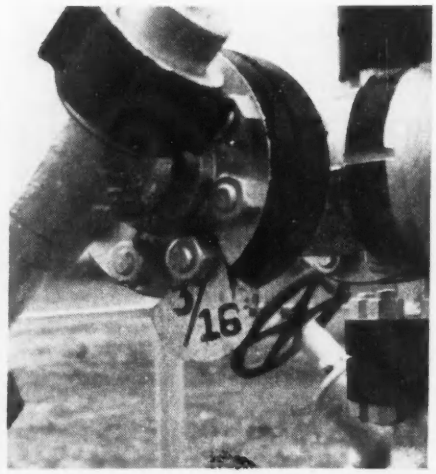


Two of the pieces of wire are fastened to the bottom of the tank, both inside and outside, and stretched over the top. The pulley wheel is then mounted at the top rim of the tank and a gauge wire run over it. A weight such as the one shown is attached to one end and a wooden float fastened to the other. Both the float and weight carry loops through which the stationary lines are threaded. As the water level rises in the tank, the float raises and the weight comes down indicating the level in the tank.

Where more accurate gauges are necessary, such as in fuel tanks, a scale may be painted on the side of the tank. Half of the weight is painted white and the other half black to show the height of the liquid within an inch.

HOW TO—Use Tab to Quickly Identify Choke Sizes

Where 2 or more switchers handle a group of leases, it is often difficult to keep up with the size of choke in each christmas tree. One company uses a tab cut from a piece of tank steel on which is painted the size of the choke. These tabs are notched and when a choke is changed, a new tab is installed. This addition is made by loosening a bolt on the flange of the wing valve and slipping the tab under the nut so that it shows toward the choke nipple.



When a supply of new chokes is bought or the holes are drilled out on chokes, a tab is cut for each choke and the size painted thereon. The tabs are then tied to the choke beans and are always kept with the chokes whether they are in christmas trees or in the warehouse.

Here's How JENSENS Cut Costs!

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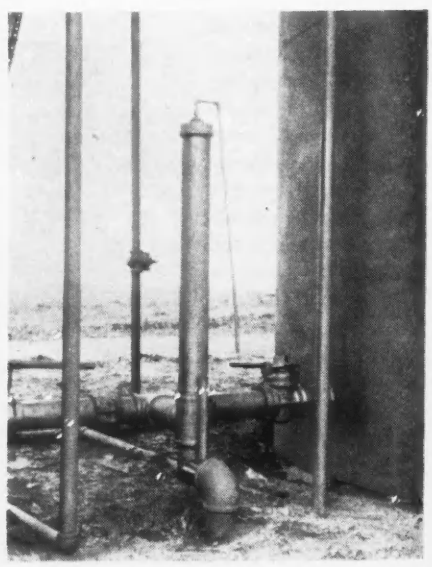
HOW TO— Prevent Air From Entering Oil Line

The only sure way to prevent air from entering the oil line when the lease tanks have been pumped out is by the



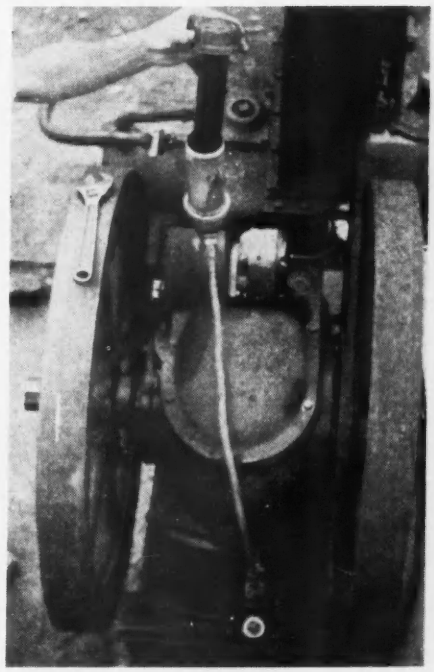
use of a float. A smooth ball floating on the oil in the tank shuts off the flow at the proper level, but it is difficult to get the ball loose once it is in the outlet connection.

One company uses the same floating ball principle, but places the ball inside a riser on the outside of the tanks. A smooth seat is placed in the outlet of a tee and also in the nipple which rises from the tee and contains the ball. When the tank is filling, the ball is held against the top seat and no long riser is needed. When the level falls in the tank to the pipe line connection, the ball floats down to the lower seat and shuts off the tank in the battery that is on the pipe line.

When the gauger comes to shut off the tank valve, he pushes down on the shaft shown beside the riser and a hinged joint at the bottom of the tee kicks the ball out of the seat. It then floats against the upper seat until it is needed again on another tank.

HOW TO—Add Relief Connection

When the oil consumption in a single cylinder engine is excessive, it may be due to too much pressure building up inside the crank case. One company fashioned the ingenious relief connection shown. Where the ¾-inch filler connection is made on the top of the timing



gears, a 2 to 1 reducer with a half-inch copper tubing connection brazed into the bottom is installed.

A 2 x 6-inch nipple is screwed into the top of the reducer and an ordinary cap screw fitted to the top. However, to relieve the pressure, the cap screw is rimmed with 9 small ⅛-inch holes. The ¾-inch nipple is threaded with a long thread to go inside the 2-inch nipple. In the top of the cap is brazed a 1¼-inch nipple so that the gas from the crankcase travels up and down and up before it reaches the holes, thus effectively scrubbing out all the entrained oil. The copper tubing connection at the bottom is tied back into the bottom of the crank case to drain the relief connection.

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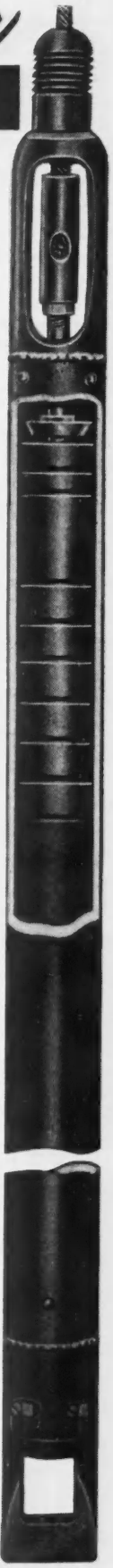

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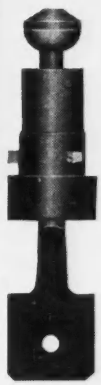

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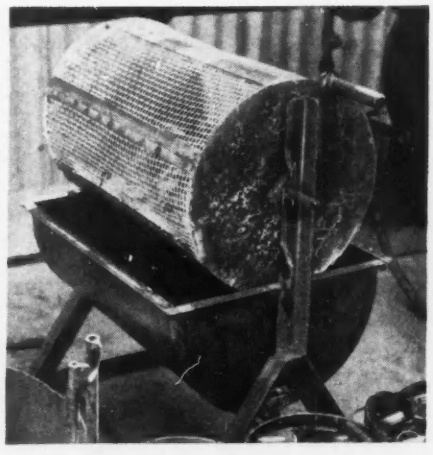
HOW TO—Make Small Parts Cleaner

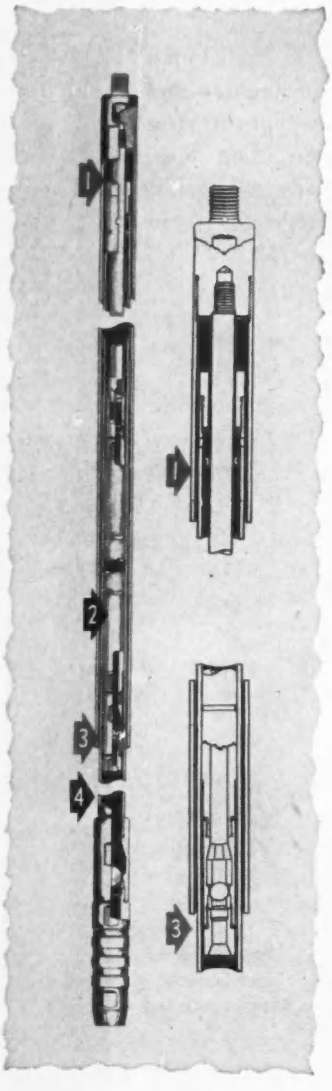
The job of cleaning the many small parts used around a shop can be simplified, and the time required reduced, by using a rotating cage-type cleaner.

Materials for construction of the cleaner include 2 circular plates for the ends of the cage, 8 metal bars welded to these ends to support hardware cloth covering, and a pin welded to the center of each end to serve as an axle. One panel of the cage is hinged to allow insertion and removal of the parts.

The vat containing the cleaning solution in which the cage is rotated is



built of sheet metal. It is suspended between angle-iron supports, which are notched for the axle pins. When the cage is loaded with small parts to be cleaned, it is lowered into the vat so that the axle pins are in the lower notches. Then the cage is rotated to clean the parts. After the parts have been cleaned, the cage is raised until it is supported in the upper notches, and the parts are allowed to drain before removal.



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This pump will give more satisfactory performance and a much longer pump life in stripper wells. It will not sand in after standing idle during proration shut-down periods. Ball-and-seat and other metal parts are available in Monel or stainless steel for highly corrosive fluids. Sizes: 2- by 1-inch, 2- by 1⅛-inch, and 2½- by 1½-inch in a wide range of barrel and plunger lengths. *Contact your favorite supply store or write us for additional details and a catalog of other* H-F *sub-surface pumps and accessories.*

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HOW TO—

Anchor Pulling Unit With Turnbuckles

Turnbuckles can be used as part of a hold-down attachment for a pulling machine for repairing pumping wells. In the concrete apron, or paved area at the derrick, eye bolts are inserted when the cement is poured, leaving the opening for the bolts large enough to make

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IN

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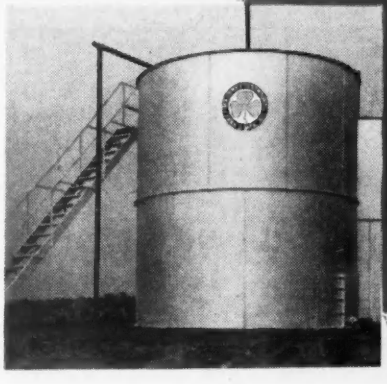
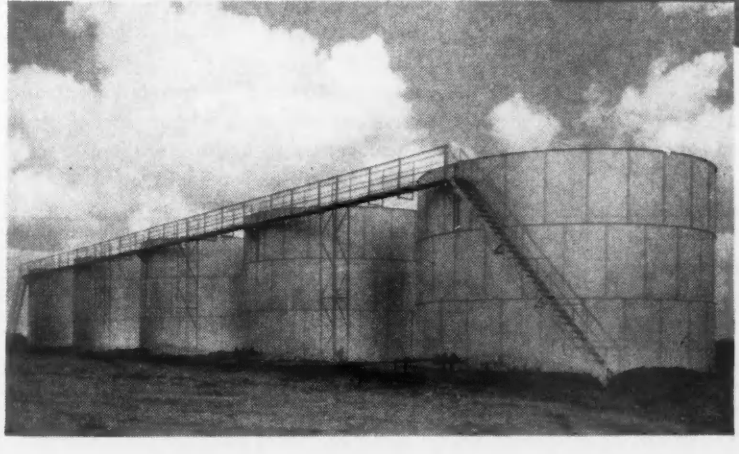


Maloney-Crawford bolted steel tanks are made to rigid (beyond API requirement) Specifications. Yet, to make sure of perfection, Maloney-Crawford makes periodic shop inspection of the plates by actually constructing a tank in the plant, as shown above. Specify Maloney-Crawford for a strong, well made product.



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TEXAS PANHANDLE REPRESENTATIVE: Atlas Tank Company, Pampa, Texas

proper connections, and sinking the top of the ring below the level surface of the apron. The bolts are spaced at the required distance from each other so the rear of the machine can be driven between each pair with adequate space between the rings and the wheels for attaching the bottom part of the adjustable turnbuckle. The machine is equipped with a 3-inch pipe, extra heavy walls, by passing it through matching holes cut in the structural steel substructure of the hoisting equipment set on the frame of the 3-axle truck.

This pipe is welded to the web of the I-beam skid member on each side of the machine to prevent turning or pulling out of the holes. It is made with extended ends reaching to a point immediately above the rings of the eye bolts set in the concrete. Each outer end is equipped with a substantial L-shaped steel latch, one end of which passes snugly into a hole near the end of the 3-inch pipe after the top ring of the turnbuckle is slipped over the end of the pipe. The lower end of the turnbuckle is fitted with a heavy clevis and substantial pin for making connection with the eye bolt ring in the concrete.

HOW TO—Handle Heavy Equipment

The need for an equipment handling device for objects too heavy for men to carry, but not large enough to justify a boom truck is answered in the material handling truck illustrated.

This handy lift truck is used for many hauls. Heavy bits, valves, short pieces of casing, fishing tools, etc., can be moved from unloading dock to storage by only one man. The truck is shown holding a gas scrubber above ground with no added weight on the lever handle.

Two salvaged automobile wheels and bearing spindles are used along with the old brake drums. A heavy piece of square steel stock is formed in a wide U-shape to serve as a frame, and a cross piece is bolted over the top to make a hook extension. A ring at the end of this short extension is attached to a short piece of chain which is wrapped around objects to be lifted.

A long lever handle is added by welding a salvaged piece of 2⅞-inch drill pipe. The end is flattened and an eye welded to it so the lift truck may be attached to a car if desired. A cross piece on the end of the handle enables the operator to guide the truck from one location to another.

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The other position is for an economist and analytical news writer, well-versed with the industry's background, economic problems, political matters and over-all general setup. Duties for both positions consist of contacting oil men to obtain data for articles and writing publishable stories. Work includes combination office and travel. Not necessary to have had experience with another magazine, but applicants should have written a considerable volume of reports or papers—and MUST LIKE TO WRITE.

State: Education, age, oil experience, writing experience, and salary expected above traveling expense.

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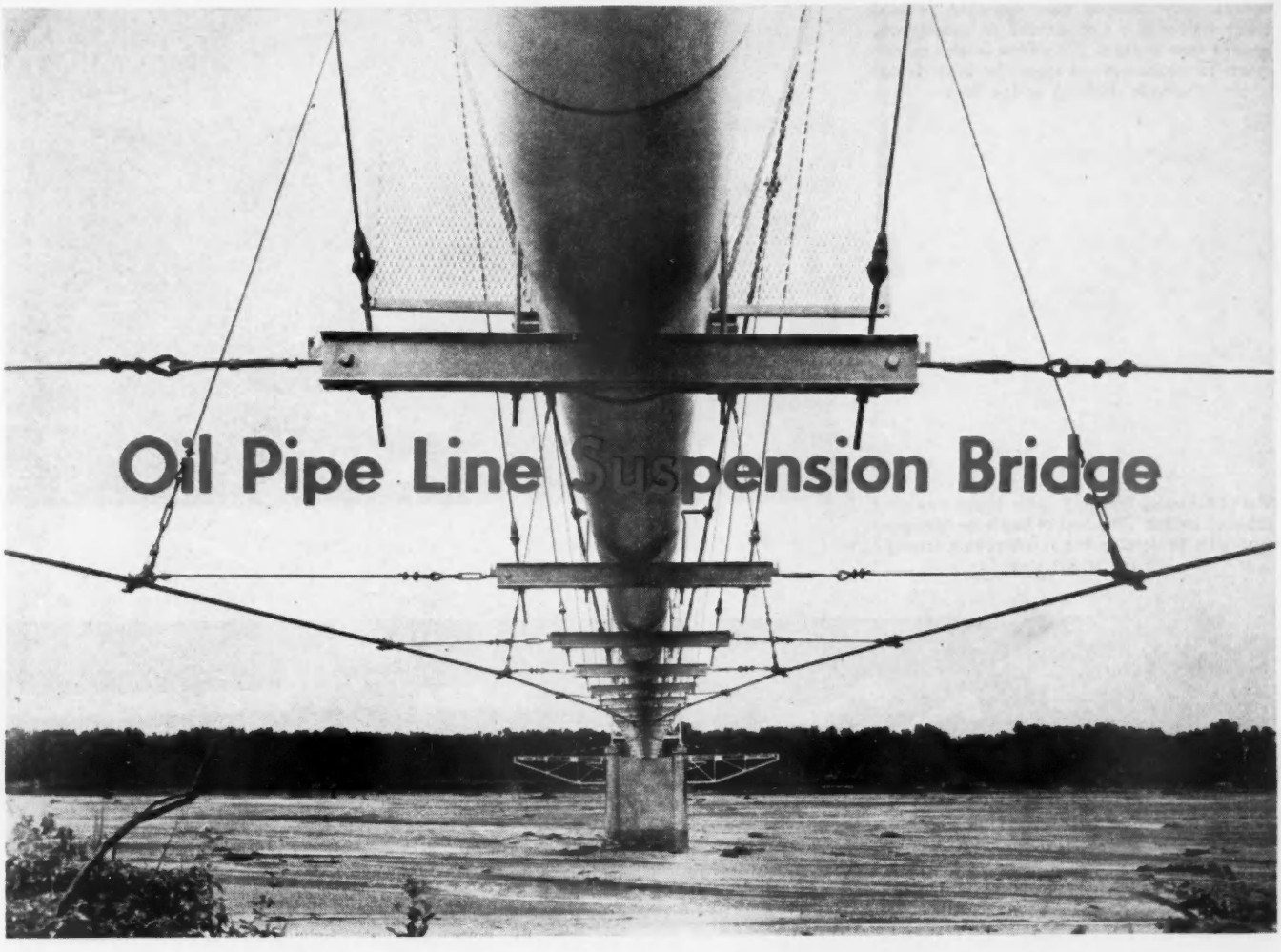
Oil Pipe Line Suspension Bridge



Even from below, this bridge exhibits graceful symmetry as the wide catenaries of the wind cables tie in to the I-beams supporting the pipe line.

SIMPLIFICATION, with consequent reduction in cost, is keynoted in the design and construction of the pipe line suspension bridge over the Canadian River near Purcell, Okla., built last year for The Texas Pipe Line Company as constructors and operators of the Basin Pipe Line System. The bridge carries a 24-inch oil pipe line across the river, a distance, from tower to tower, of 1800 feet, divided into 3 600-foot spans. Present loading is 280 pounds per foot, but the bridge is designed for a future maximum load of 482 pounds per foot. The back stay spans measure 231 feet and 154 feet, 6 inches, respectively, making the total length of the bridge 2185 feet, 6 inches from anchorage to anchorage.

The structural steel towers rise 53 feet above the reinforced concrete piers which are supported on steel H-piling. Each of the 600-foot spans is slightly cambered so that with final full loading the pipe will not sag lower at the mid-span points than at the towers.

The main cables, although among the largest strands ever used in a bridge of this type in the U. S., were handled and erected with none of the difficulties previously associated with strands of such large size. They are 2 5/16-inches in diameter, 1 x 121 wire, zinc-plated bridge strands, pre-stressed at the factory to uniform elasticity. Each has a minimum breaking strength of 327 tons.

Simplification of the main cables contributed markedly to the reduction in the cost of the bridge. To obtain a breaking strength of 327 tons with material previously available would have required two 1⅝-inch bridge strands, with corresponding complication of attachments and anchorages, or one multiple-strand bridge rope of at least 2⅝-inches diameter with somewhat less desirable elastic properties.

PIPE LINE bridges of the suspension type are fairly common in gas trunk-line practice, but are a comparative novelty in the design of large-diameter oil pipe lines, where the additional weight of the fluid adds to the working load on the bridge and the possibility of line surges or vibration adds further stress considerations.

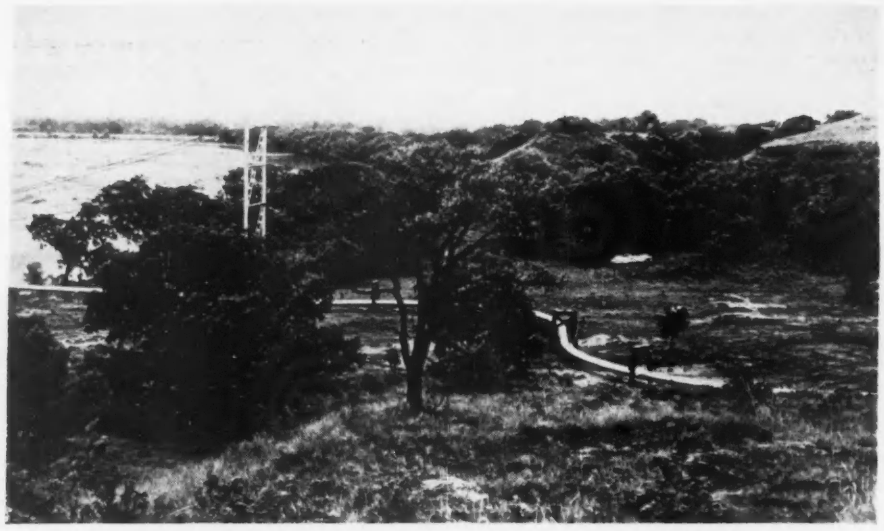
Bridge strands of even larger sizes, up to 2 9/16-inches diameter, with 392 tons minimum breaking strength, are now available and are recommended by the manufacturer without qualifications. They may be obtained in continuous pre-stressed lengths up to 4000 feet.

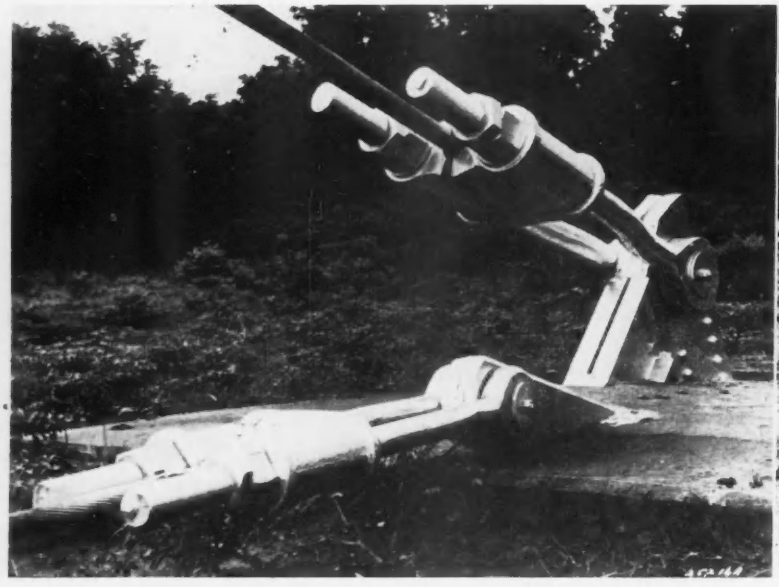
All suspender locations were accurately measured and marked while the strand was in the pre-stresser under a tension equal to the working load of the bridge. The same procedure was used for the wind cables, which are 2198 feet long, 1 7/16-in. diameter, 1 x 51 wire bridge strand, zinc-plated. Support, saddle and brace locations were marked under working load in the pre-stresser.

Galvanized steel rods were used for the shorter pipe-cradle suspenders, up to 15 feet long, and ½-inch diameter, 7 x 7 galvanized bridge rope for suspenders longer than 15 feet. The same type rope was also used for the wind-cable brace and support ropes. Altogether 6036 feet of auxiliary ropes were required.

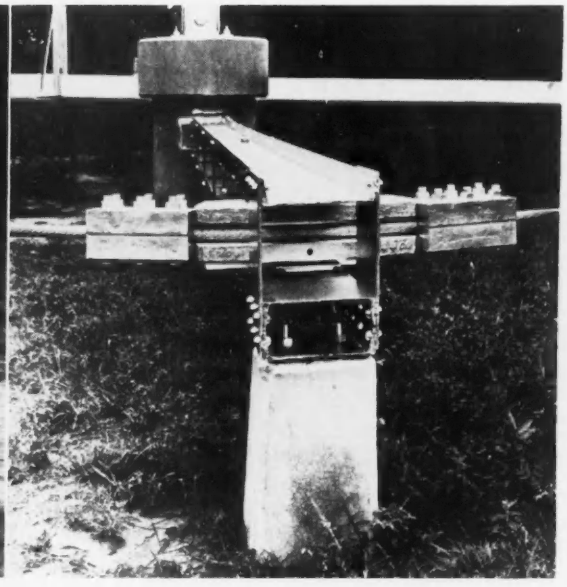
To prevent eccentric loading during the first filling of the pipe, water was pumped simultaneously into each of the high points of the mid spans. The pipe then remained full thereafter.

General view showing pipe approach to land tower with wide S-turn carried on saddles suspended from bents so as to allow lateral adjustment to expansion changes in pipe length without stressing bridge line.

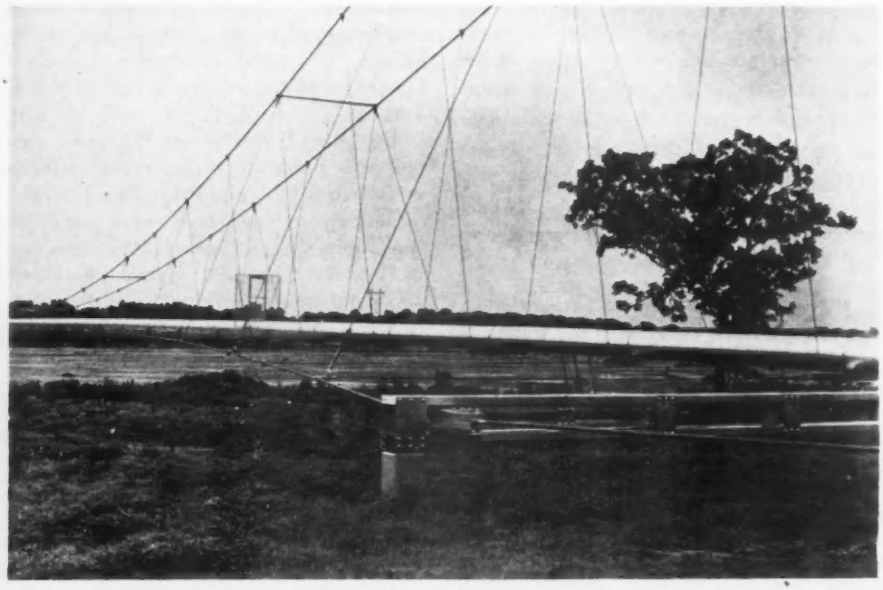




Main anchorage for main cable at top and wind cable at bottom. The socket bowls are designed especially to develop the full breaking strength of the bridge strand.



Detail of wind cable support strut. The cable is carried in a formed saddle, and held longitudinally by two clamps. The support strut is pivoted to allow equalization between span and anchorage sections of cable.



In foreground is one of the hinged wind cable supporting struts which provide adjustment as the continuous wind cable stretches or contracts under varying wind loading.

Measurement and Control of High Pressure Gas

By A. F. KRAUS

Superintendent of Gas Measurement, The Peoples Natural Gas Company

SEAMLESS pipe, compressor improvement and mechanical methods for laying pipe sparked the rapid increase in the nation's network of pipe lines. In 1947 there were 243,000 miles of natural gas lines while interstate transportation of gas rose from 200 billion cubic feet in 1925 to 1.3 trillion in 1947. It is estimated that about 260,000 miles of natural gas lines will be operating in 1952 capable of delivering 9 trillion cubic feet of gas annually.

Gas is being used for many purposes in industry and is a welcome addition to any home. Deeper drilling is opening vast new producing areas, and economists have estimated that, by the end of 1955, the U. S. will have proved reserves of about 200 trillion feet—even with rapid consumption increases, as in the past few years.

Use of gas in 1947 was up over 137 percent as compared with 1929; oil, up 84 percent, and soft coal, 16 percent.

The increase in gas was partly due to new uses found for gas, but more important, perhaps, was the matter of cost. Today, gas is the cheapest fuel. And so the trend toward greater use of natural gas continues. How long and how far this disproportionate increase goes depends considerably on how long present price differential continues.

For several years something has been done about the problem of delivering gas in quantity at the times of peak demand. Unlike coal and oil, gas consumers do not have a full bin or tank at their call.

Gas comes from underground reservoirs, which were nature's storage places in the beginning. Some areas that need gas today have depleted gas fields at hand—probably the finest type of storage tank in the world. And so companies are using these old fields near their markets by reconditioning old wells and pumping gas into the ground during the summer to await peak demand during the winter.

Other Storage Methods

Other methods of gas storage include the case where gas is forced under high pressure into a series of buried "coils" of extra heavy pipe. In another case, the gas is liquefied above ground at more than 250 degrees below zero Fahrenheit. Methane becomes a liquid at that temperature, and as a liquid, it occupies a comparatively small amount of space so that 600 cubic feet of gas becomes one cubic foot of liquid. Obviously, there is a large saving in storage space, but the gas must be kept at that low temperature until it is wanted, and thus, this experimental method is frequently too costly even to consider.

MEASUREMENT OF gas under trunk pipe line conditions is investigated by the author, and recommendations are made for standardizing conditions so that consistent readings of pressure and volume values can be obtained within limits which will adequately provide a check on throughput. Snubbing or muffling of compressor impulses in the gas stream is recommended for accurate measurement of discharge side values, and types of devices and hookups for attaining uniform flow are fully described and illustrated.

Gas measurement engineers are ever striving for greater efficiency but the goal is far removed. Problems are invariably encountered and present many and varied obstacles hardly ever even recognized by the casual meter station observer, much less by those entirely unfamiliar with the subject. Frequently, problems encountered seem identical with those previously dealt with, but always there seems to be found a different condition that serves as an impediment until it is removed or somehow overcome. This paper will treat briefly with problems of high pressure gas measurement and control.

Displacement type meters are generally used only to measure comparatively small volumes and usually at line pressures below 200 pounds.

The orifice meter is a widely used type of meter for measuring differential pressure, due to its basic advantages in satisfactorily measuring a wide range of volume in an almost limitless variety of circumstances and conditions. The orifice meter can be used for all the various temperatures and pressures encountered in the gas industry. Adaptability to such a wide variety of conditions undoubtedly makes it the most versatile of all measuring devices.

Possible disadvantages of the orifice meter are far outweighed by the inherent advantages in its application to flow measurement problems generally. From the standpoint of cost, the primary and secondary devices can be purchased at nominal cost for any job and can be depended upon to give years of satisfactory service.

With normal care and attention, main-

tenance and repair costs will also be relatively low. Frequency of periodic tests and inspections are usually in direct proportion to the severity of the service and the desired maximum degree of accuracy of measurement. The comparative ease of changing plates, and the pressure range of the meter are other distinct advantages.

AGA Standards

Whether the orifice meter installation is to be used for low-pressure or high-pressure measurements, the installation must conform to standards as set up by American Gas Association and published in its Orifice Meter Report No. 2. The conditions used in the basic calibrations were those obtained by long, straight runs of commercially smooth pipe. Inasmuch as it is not always possible to obtain ideal conditions, allowable limits of deviation from ideal conditions are set up in that report. These tolerances must be strictly respected if dependable, accurate measurements are desired. All meter equipment, meter runs, pipe, valves flanges, etc., must, of course, have sufficient rating and be properly fabricated to withstand maximum stress and pressure to be encountered in operation.

Regulators, or preferably air-operated, pilot pressure controllers and control valves, are frequently necessary in connection with high-pressure orifice meter installations; sufficient piping and straightening vanes should be allowed to eliminate turbulent flows thus created.

Figure 1 is a schematic diagram of a pilot-type, air-operated, automatic pressure controller used to maintain a constant pressure in the downstream or outlet line from a diaphragm valve.

Assuming that the controller is to maintain a constant downstream pressure in a pipe line, the operation is as follows: Auxiliary air (or gas) pressure enters the pilot through a regulator and passes into the orifice block through the fixed orifice to the bleed nozzle. The opening at the nozzle is controlled by the flapper, which, in turn, is actuated by the movement of the bourdon tube. The free end of the bourdon tube moves in accordance with the variations in the downstream or controlled pressure, which is piped to the pilot and into the tube.

When the downstream pressure increases, the increase is transmitted to the bourdon tube. This results in partially closing off the bleed nozzle, thereby admitting back pressure to the diaphragm valve. This action provides partial closing of the control valve, and the downstream pressure again returns to the set point. The reverse action takes place should the downstream pressure fall below the set point.

Adjusting Control Point

This figure also shows the method of adjusting the control point. The control point may be varied by turning the adjustment screw, which pivots the base plate on the pivot bolt and thus changes the position of the flapper. There is also incorporated in the pilot a throttling range adjustment pin, which in effect is the pivot pin for the flapper. This adjustment makes it possible to vary the amount of pressure change necessary to open or close the valve. It should be remembered that, in actual practice, the diaphragm valve is seldom closed or completely open. It usually is a throttling valve and floats, as it were, between the open and closed position. The pilot valve assembly may be remotely mounted on a panel board if desired, or it may be mounted near or on the control valve, or it may be an integral part of the diaphragm assembly of the main control valve.

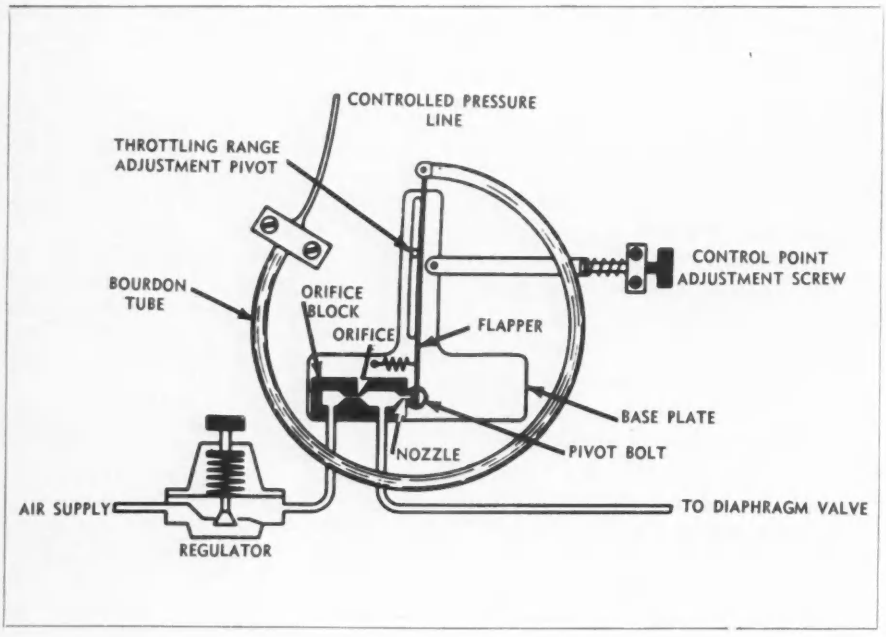


FIGURE 1

Types of Pilots

These pilots can be either direct-acting or reverse-acting and can be used with various types of direct or reverse-acting diaphragm control valves. Several types are available and the gas operator or field man should further explore their operation and the many advantages they offer in high pressure regulation.

If the measuring station is well removed from a pumping station, the very troublesome pulsation problem will usually be eliminated or reduced to a minimum. Where pulsation is found, it can at times be eliminated by a restriction orifice or pinched plug valve. The loss of pressure thus caused is not sacrificing pipe line efficiency, unless the station is measuring the main line gas being transported. At distributing points along the line, this comparatively insignificant pressure loss is usually of no consequence. Where high pressure gas is measured from a storage pool pump stations are usually employed and some pulsation may be encountered. Every effort must be made to eliminate the resultant error. Loss of pressure due to the use of an orifice restriction plate to remove pulsation may rule this procedure out of the question due to extra horsepower required and extra compressor maintenance.

Figure 2 shows the general arrangement of other pulsation dampeners used with a satisfactory measure of success in a number of installations. With these pulsation dampeners at our pumping stations, the length of the larger pipe seemed very important. Too much pipe was as worthless as too little. Gas volume, large expansion pipe capacity, type, number and speed of engines all had to be considered. Note all these pulsation dampeners employ change of direction principle and that the flow in and out of the reservoir is to and from the side wall of the reservoir.

Supplying gas from storage pools with probably attendant vibration in high pressure storage gas measurements poses additional problems. Most storage pools, for example, in the Appalachian area, are so wet that the gas moved from its natural storage area is appreciably saturated. Drips properly sized, designed and located at the wells, along the line

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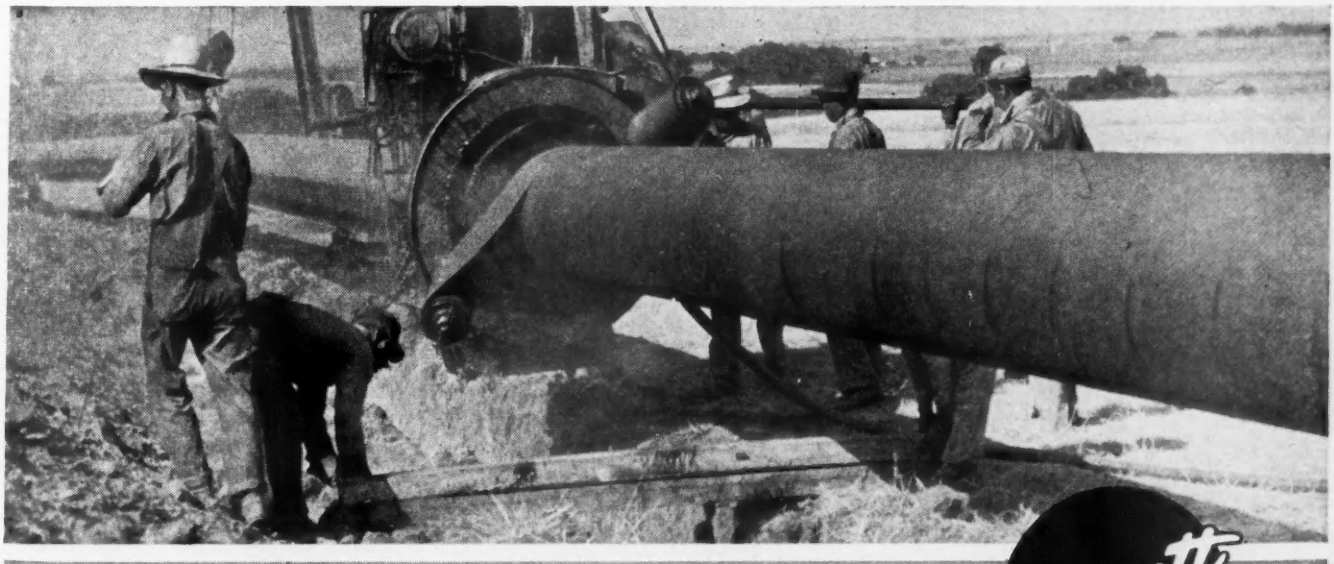

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and at the meter station, will be of some help in eliminating this problem. Separators and liquid knockout equipment are now on the market and can be used with recommended liquid particle and dust particle elimination equipment. A thought worth remembering is to measure gas into storage on the suction side of the station and let the drop in pressure through the oil scrubber help eliminate or absorb the pulsation. Best results will be more readily obtained if gas out of storage is measured after the pressure is reduced to desired main line pressure or on the suction side of the station if it is necessary to pump the storage gas to market. Caution should be exercised so that vibration will not be created in the measuring station.

Contracts Specify

Pipe line contracts usually specify amount of gas to be taken or delivered each day. This provision usually causes an air-gas operated flow controller and control valve to become an important part of the station installation, and here again, orifice to pipe diameter ratios, size of inner valves of control valve, size and length of pipe runs, possible vibration and need for straightening vanes, must be checked. The orifice used for measurement can be used to operate the flow controller or another installed at the control valve for that purpose. The operation of the flow control instrument is similar to the pressure control instrument which has already been described.

Where high pressure gas is taken from a main trunk line and delivered to a customer at a reduced pressure or where gas is taken from a storage pool and delivered into a main line at reduced pressure, it is generally found more satisfactory and economical to measure the gas at the reduced pressure. This, however, causes other complications, since the high pressure incoming gas is usually at a temperature of about 40° F., and generally speaking, a reduction of one atmosphere usually causes a drop of about one degree in temperature. A pressure reduction from 1000 pounds to 250 pounds would accordingly, without further consideration, cause a 50-degree drop in the gas temperature. This cannot be permitted without further study and correction since, where this pressure-temperature relationship would cause the gas to be in the hydrate stage, the main piping, valves and regulator would frost; ice would form on the outside of this equipment to the point where it would become dangerous and could not be operated; also hydrates would form on the inside of the pipe, on and in the orifice, rendering the measurement registration totally unreliable; ice would form on the pressure regulator or control valves to the point where the flow would be partially, if not completely, cut off permanently or at least intermittently.

Problem Increases

This frosting, ice formation and hydrate problem is not new in the industry but has increased and grown proportionately with the long, high pressure gas transmission lines and storage pools. In pressure reduction work, expected outlet gas temperatures must be carefully reviewed, since the resultant gas temperature may be at or below the dew point.

Methods Change

Methods of combating this freezing and hydrate forming have changed with the necessity of larger pressure reductions. Better regulation will be had and many freezing problems can be eliminated by more carefully selecting proper type and size of inner valve for the pressure controller. A dehydration plant may partially or entirely eliminate the freezing problem in addition to increasing pipe line efficiency made possible by elimination of water in the pipe line. Experience confirms reports from pipe line operators and station attendants that freezes usually occur in connections about measuring stations and in a pipeline on a riser or rising slope out of a sag or low point. Percolating action of the gas as it passes the water lying at the low points seems to favor freezing or hydrate formation. Sufficient compensation by way of increasing the gas temperature before pressure reduction is frequently necessarily resorted to in order to eliminate this problem, which is attended with costly operating difficulties, trouble with pressure regulators or control valves and measurement errors. Engineers specializing in heating problems should be consulted in designing equipment involving such problems. Each heater and heat exchanger should be designed for a specific job and for certain conditions. Commercial counter-flow heat exchangers should be used instead of the inefficient and antiquated burners under casing around the gas line carrying the gas, the temperature of which is to be raised. Passing steam or hot water through a jacket welded around the pipe line is also effective. Steam jacketed regulators through which steam circulates, and electrically heated valve seats have also been successfully used.

Type and size of heat exchanger required for any particular job depends on volume to be handled, amount of pressure reduction, incoming gas temperature and the temperature required to maintain operations outside hydrate formation zone. Hot water or steam boilers furnish the media for operating the various efficient heat exchangers and these modern well-engineered gas boilers can be equipped with automatic controls to maintain delivery gas temperatures at any predetermined point. This is certainly a far cry from haphazard and dangerous fire pits formerly used.

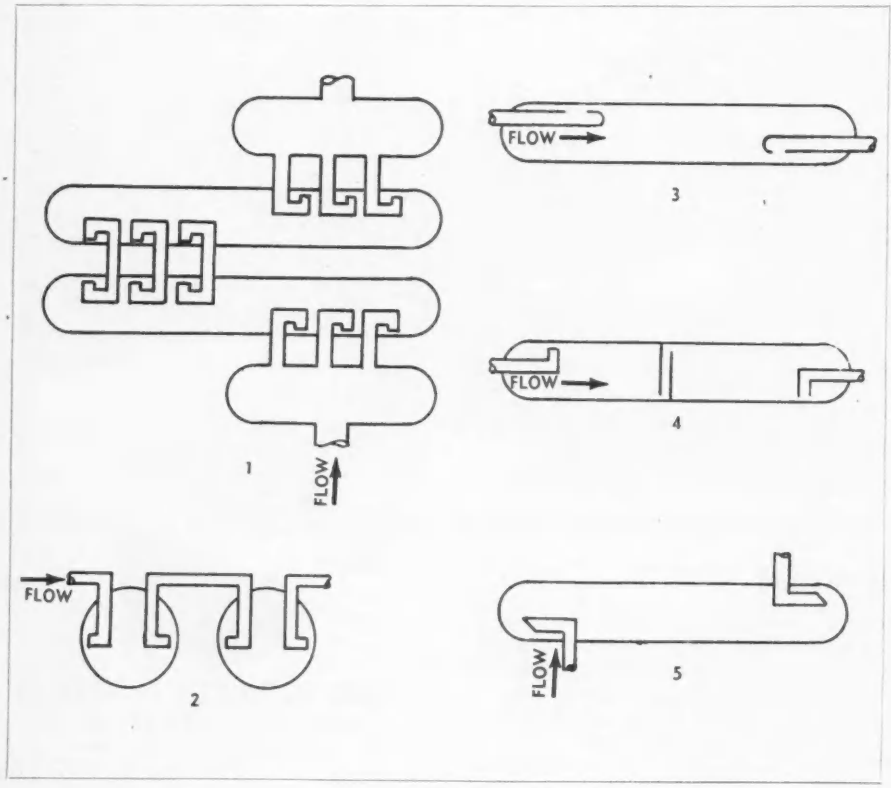

FIGURE 2

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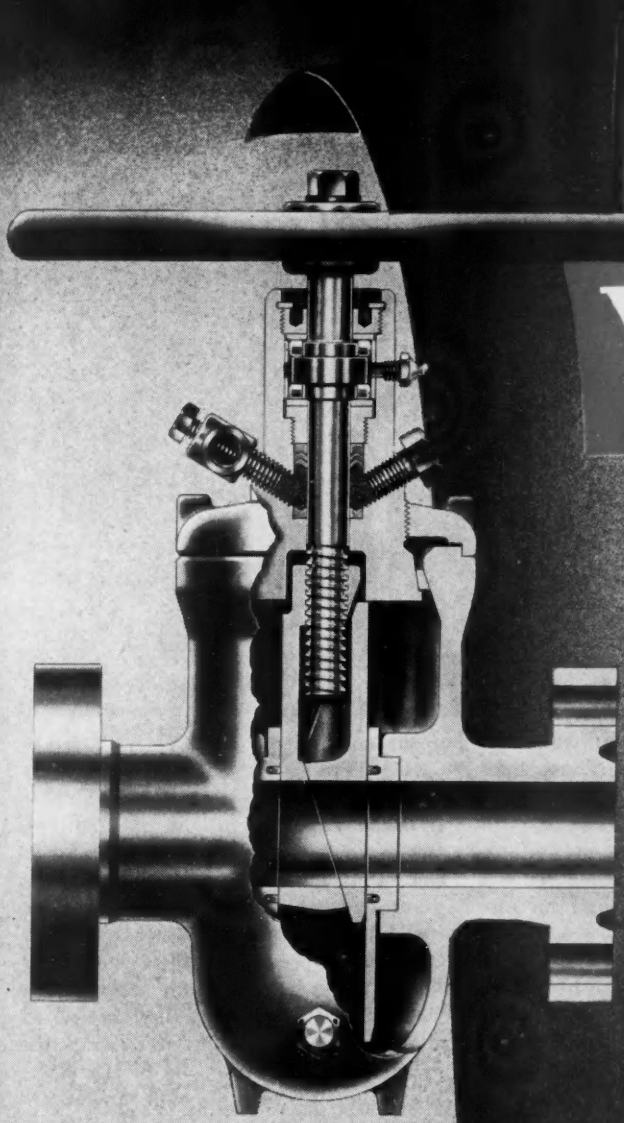

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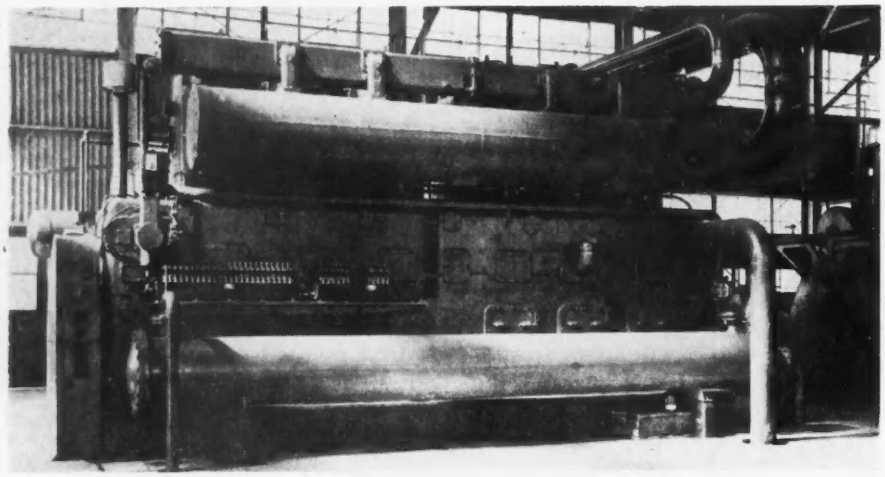

PROCEDURES for starting engines vary in accordance with the ideas of individual field men, with the result that inexperienced personnel may use dangerous methods, creating safety hazards and damage to equipment. To meet this condition, one Mid-Continent operator prepared a set of rules which, although not designed to constitute a complete set of instructions for all makes and types of engines, covers a wide field and has paid off in fewer accidents and greater operating efficiency.

The rules set forth are for the guidance of field personnel in general.

(1) Four-cycle engines should be turned 2 complete revolutions with all indicator valves open. Do not relieve compression by hooking up exhaust valves. Use indicator cocks instead. This is to prevent water accumulation in cylinders from being forced out into exhaust ports where it could drain back into the cylinder and be trapped when starting, resulting in bent connecting rod.

Two-cycle engines should be turned 1 complete revolution with all indicator or relief valves open. This is to make sure that everything is free of obstructions and that there is no accumulation of water in the cylinders.

(2) Spot engine in starting position by barring in direction of rotation.

(3) Gauge intake lines for water accumulations. Also gauge exhaust lines on engines that have a separate exhaust riser to each cylinder.

(4) Turn on 25 to 30 pounds of injection air and prime fuel lines. This is to keep fuel oil from backing up into injection air lines.

(5) Blow out injection air piping where this piping is provided with bleeder valves. If any fuel oil shows up at this point, all injection air piping must be removed from the engine and cleaned with a solution of hot soap or lye water before attempting to start the engine.

(6) Open drains on low and intermediate stages of air compressors.

(7) Turn on small amount of water over all cylinders and increase after engine is in operation (applies to open water systems only).

(8) Turn on lubricating oil if engine is of the gravity lubricated type.

(9) Open valve admitting air from air compressor discharge line to injection air bottle. Open injection air valve admitting injection air to all spray valves except on those engines which have an open spray valve while in the starting position. This could cause engine to roll off the starting position.

(10) Set fuel pump so that no fuel oil is admitted to starting cylinders during period that starting air is being applied to these cylinders.

(11) Turn on starting air *as slowly as possible* without losing the start. Explosions may occur due to opening the starting valve too rapidly. Under such conditions the rush of starting air compresses air in cylinders or liners and fires fuel oil in the same manner that it is fired by compression in the cylinders.

(12) After other cylinders are firing, shut off starting air and turn on fuel to starting cylinders. Failure to observe this instruction may cause one of the starting cylinders to fire with an excess charge of air in the cylinder. A condition of this kind develops a tremendous explosion in the cylinder, often resulting in a bent connecting rod and a badly damaged engine.

(13) Close compressor drains, regulate injection air, and refill starting air bottles.

(14) Watch bearings, lubricating oil pressure, and injection air regulation closely for first 15 to 30 minutes until it is definitely known that engine is operating normally.

(15) Do not put load on engine until it has had sufficient time to warm up. The unit should be operated idle for 20 or 30 minutes if started in cold weather and with cold water flowing over the cylinders. Failure to do this may result in piston seizure or cracked cylinder heads.

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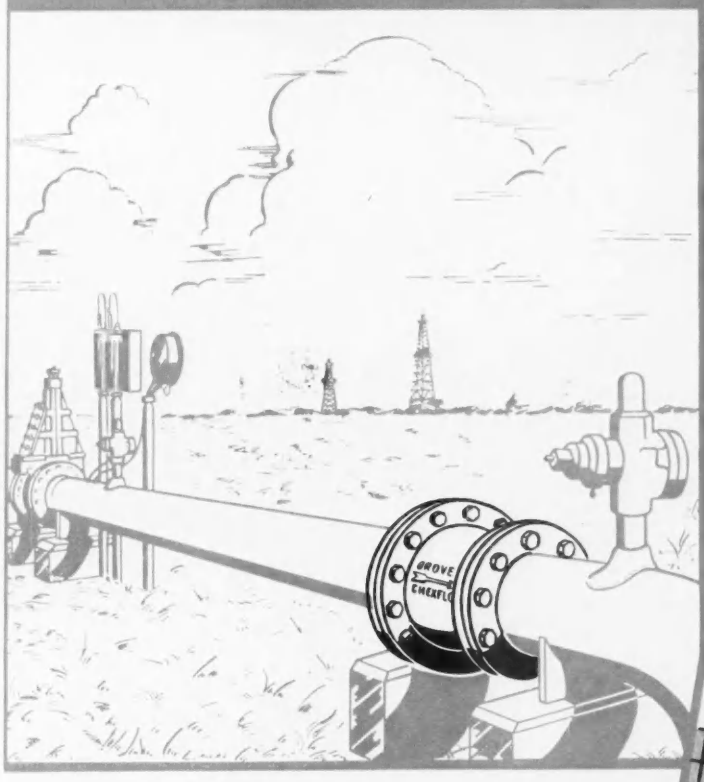

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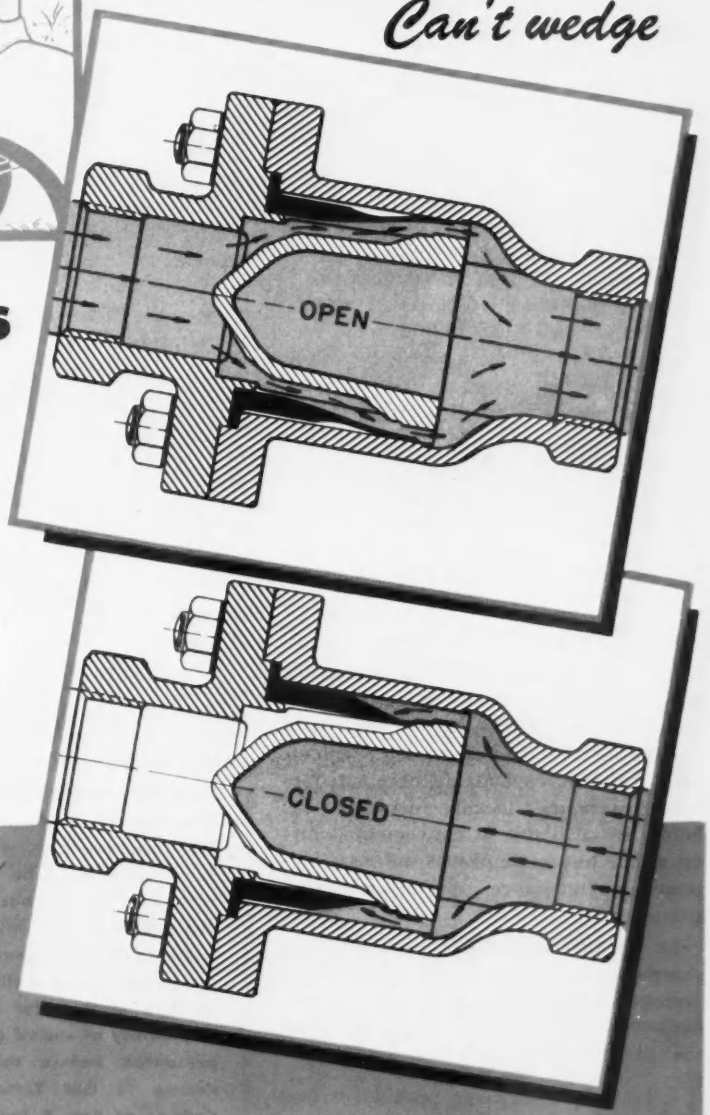

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Underground Storage of Natural Gas

By W. R. KUBISTA

Chief Engineer, Oklahoma Natural Gas Company

IN A recently completed study by Max W. Ball, the importance of gas storage fields to natural gas operations was clearly indicated by the increase in the number of storage fields from 24 in 1939 to about 80 in 1949.[1] According to the joint study of the AGA and API Committees on Petroleum Reserves, the volume of gas in underground storages as of December 31, 1949, was 258 billion cubic feet. The total operating capacity of the known storages is estimated to be approximately 441 billion cubic feet.

Oklahoma Natural Gas Company has operated 2 storage fields since 1944 and is currently placing in operation a third. The first 2 have a volumetric capacity of approximately 12.5 billion cubic feet while the latter has a capacity of 50 billion cubic feet. Prior to 1944 the company developed a small storage, which was abandoned in 1941. This paper will present some of the company's experiences with storage reservoirs and storage operations. Volumes used herein are referred to a 16.4 pounds per square inch absolute pressure base at 60° F.

Reasons for Storages

In general, the load characteristics and operating problems of natural gas companies are such that underground storage fields provide the most economical volumetric capacity. Where satisfactory reservoirs, usually depleted gas fields, are available at convenient points on a pipe line system, it is indeed a fortunate circumstance for the operating company.

In all probability every natural gas company has or may have need for some storage facilities, and although the reasons may vary slightly they do follow the same general pattern:

1. To help meet large peak loads and occasional emergencies.
2. To improve system load factors and to better use existing line facilities.
3. Conservation of gas otherwise wasted because of a lack of markets.
4. A means of recovering and saving an equitable share of reserves in highly competitive supply areas.

Oklahoma Natural Gas Company is currently placing in operation a storage with a volumetric capacity of 50 billion cubic feet or 4 times the capacity of the 2 storages previously developed. Although a storage of this magnitude on the Oklahoma Natural system will greatly improve load factor, it has been developed primarily for a reason which in recent years seems to have become more and more important throughout the natural gas industry generally. Herein it will be called the gas purchase factor. It simply means that an increasing proportion of the natural gas supply is coming to the gas pipe line operators in the form of residue gas from gasoline plants on a 100 percent purchase, take or pay basis. Unlike dry gas fields, residue gas cannot be turned on and off like a water faucet to meet varying demands. It therefore follows that as the proportion of residue to dry gas increases it becomes necessary to provide some flexible means of balance between supply and demand. Oklahoma Natural is now facing such a condition and has chosen to meet it with a relatively large underground storage.

FACTORS WHICH influence the acquisition of underground storage facilities, together with the problems which must be solved before such storage can become effective, are discussed in this article. Precautions to be observed in plugging or reworking old wells are outlined, as is a method for predicting deliverability of stored gas. This paper presented before the 1950 Short Course in Gas Technology, Texas College of Arts & Industries, Kingsville, Texas.

Preliminaries

Once the need for storage facilities becomes apparent, the management begins to ask numerous questions, the principal ones being:

1. Where can a convenient storage be found?
2. How big should it be?
3. What about its deliverability?

If reasonable answers can be found then come:

4. Can the area under consideration be leased for storage?
5. How much area should be leased?
6. What will the project cost?

The company's early experiences showed the importance of very careful investigation and study of all fields under consideration in order that intelligent answers might be given. Suitable depleted or partially depleted fields are not always easy to find, nor are they always conveniently located with respect to the markets or an adequate pipe line system. Furthermore, after the volumes to be stored are determined, it is seldom that a field can be found which is tailormade to the requirements.

Usually some sort of compromise is indicated between the requirements and what may be available as determined by the study of performance records.

Probable Deliverability

Predicting the probable deliverability of a given field frequently resolves itself into estimating the order of the magnitude. Where good past performance records of wells are available it is often possible to predict deliverabilities with a reasonable degree of certainty. In par-

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tially depleted fields it may be possible to obtain back pressure tests on remaining wells to provide reliable information.

When a field is found favorable for storage, it goes without saying that steps must be taken to lease the area in a solid block. This leads to the question of how much area should be leased. Some irritating experiences in the past with stored gas migration clearly indicate the importance of careful geological evaluation of any chosen field and a determination of the useful reservoir perimeter as closely as available data will permit. Too frequently, however, such data are inadequate to determine reservoir limits with any high degree of reliability and the Oklahoma Natural as well as other companies have found it desirable to obtain leases to boundaries considerably beyond the estimated reservoir limits.

The ease and readiness with which leases and storage rights may be obtained and the reasonableness of cost depend on a number of things. Chief obstacles:

1. Occasional grievances and grudges against the company by royalty and mineral right owners carried over from past production problems, litigation, regulatory conflicts and and other difficulties.
2. A reluctance to complicate the possibility of exploring or producing other previously unexplored strata in the area, or of existing production.
3. Ignorance or misunderstanding of the scheme of underground storage by owners of leases and rights to the extent that it requires numerous personal contacts and great patience in presenting the story.
4. The hard traders who hold out for unreasonable remuneration.

In a few states relief and protection have been provided in the form of special statutes for condemnation proceedings.

Estimating Cost

Finally, an effort must be made to estimate the cost of the project. This obviously will depend on the size of the storage, number of wells required, and numerous other local conditions. In a recent study, costs were reported to range from 2 to 53 cents per mcf of "usable" capacity and including such items as acquisition, lines, surface and well equipment and cushion gas but excluding compressing station and dehydration equipment.[1] Costs of two storages developed by Oklahoma Natural on the basis given above were 16 and 13 cents. Usable capacity as used here means that volume between the expected top operating pressure and the lowest operating pressure, leaving the desired cushion. It does not necessarily mean annual turnover which may vary from year to year.

Storage Wells

Obviously there must be a sufficient number of wells in any storage field to achieve in any given pressure range the deliverability planned for the project. Up to a certain point, the greater the number of wells, the lower the reservoir pressure required to produce a predetermined minimum deliverability. Beyond that, additional wells might cause a spacing so close that the flow of gas within the reservoir would be such as to cause interference between wells and relatively little further increase in total deliverability.[2]

When to drill new storage wells and when to recondition existing wells depends largely on what the operator has to start with. In general, it has been the practice among operators to drill new wells where existing wells could not be satisfactorily reconditioned or where there was doubt as to condition of well equipment. Oklahoma Natural has reconditioned a number of wells in 1 of its 3 storages because conditions favored such work. In this instance the reservoir was relatively near the surface (800 feet), and the casing could be pulled and new casing run and cemented with ease and wells recompleted at reasonable cost. Also of interest may be the fact that several old plugged holes, which were leaking, were cleaned out and recompleted successfully into storage wells.

Because of the permanent nature of each storage and the investment involved it has been the policy of this company to complete wells carefully, cementing the casing string from bottom to surface wherever possible or at least through all salt-water bearing strata. All wells were drilled into the reservoir sand with cable tools and in nearly every instance the entire sand section penetrated to give the best possible deliverability characteristics. Christmas trees and well equipment were designed for pressures in excess of the original reservoir discovery pressures.

Location of the wells followed no particular pattern, the emphasis being on choosing areas of good permeability as indicated by performance records of old wells. However, wells have been spread well over the productive part of each reservoir in order to achieve as far as possible a uniform pressure distribution and thereby the advantage of the best possible outflow and injection characteristics.

Field Lines and Equipment

In any storage field where the potential performance of the wells is to be utilized to the best advantage, the field lines should be of adequate design to permit as far as possible under field operating condition a reasonable uniformity of flowing pressures throughout the system.

Cleaning of injection gas to protect the sand face in the wells and dehydration where pressures and gas temperatures warrant, are, of course, generally accepted practices throughout the industry.

Experience has shown the desirability of good operating and performance records, which means the installation of good pressure, volume and temperature measuring equipment. The Oklahoma Natural Gas Company has made it a practice to install measuring equipment at each well in addition to a central measuring and regulating station. Such equipment at each well permits periodic back-pressure tests to check well performance and is the means of detecting changes in well flow characteristics. Careful shutin pressure readings at the wellhead together with accurate measurement of input and output volumes at a central measuring and control station furnish the only day-to-day data on reservoir performance. Where slow stabili-

About the Author

W. R. KUBISTA was graduated from the University of Wisconsin in 1926 with a degree in chemical engineering. He was associated with Wisconsin Power and Light Company as gas engineer for 3 years. For 13 years he was with Central States Power and Light Corporation and Utilities Production Corporation in Tulsa. During the past 3 years he has been chief engineer of Oklahoma Natural Gas Company.

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zation or substantial pressure differentials occur across a shutin reservoir, many storage operators provide "pressure" wells. These are situated at regular intervals over the reservoir and are left shut in and are equipped to furnish a continuous reservoir pressure record. Although such a record, in all probability, does not furnish sufficient reliable data for determining the weighted average pressures of a reservoir with substantial pressure differentials, it is the writer's opinion that it at least supplies a means of comparing the relative cyclic performance from year to year.

Operating Experiences

A storage field which has been developed from a depleted producing area with numerous plugged holes in it always offers the risk of leakage of stored gas through improperly plugged wells. The company with which the writer is associated recently experienced difficulty with six improperly plugged wells which developed leakage at the surface and possibly into permeable strata other than the reservoir sand. The company's practice of maintaining a regular patrol of the storage area made speedy action possible and probably prevented blowouts. Remedial work consisted of running tubing into the hole as far as possible and then circulating mud until each well was killed. Following this, old tubing left in the holes, iron, packers, etc., were cleaned out and the holes replugged, using cement through the reservoir sand. In some instances the wells were recompleted as storage wells if flow characteristics and condition of the hole warranted such procedure. It is noteworthy that a well was recompleted after being plugged for nearly 20 years, having an open flow volume of 41 million cubic feet per 24 hours at 270 psi reservoir pressure.

It is believed by the writer and his associates to be good practice to set cemented surface casing in old holes which are suspected or known to be improperly plugged and possibly in those which are doubtful. Such equipment, it is believed, would provide a means of getting remedial work started, particularly in the event of a blowout.

Finding Old Holes

One interesting method of finding old holes, the exact location of which was concealed by the action of the elements, was developed by operating personnel. It consisted of cutting down the general surface area around a probable well location with a bulldozer. Surprisingly enough, the differences in color of the subsurface soil would in many instances show the route of the old well line ditch backfill and thereby lead the hunters to the obscured hole.

The best operating pressure range of any given storage is largely determined by the amount of turnover desired and the maximum and minimum deliverability expected at any given time in the operating cycle. In this connection the question often arises: Is it permissible to operate a storage at a pressure which would exceed that which existed in the reservoir when it was initially produced. Insofar as the rocks are concerned, it is the writer's opinion that little or no difficulty would be experienced even with pressures considerably in excess of the discovery pressure. It has been reported that more than 17 storages have been successfully operated at top pressures exceeding discovery pressure.[1] However, before such an operating practice is adopted, two important factors must be considered:

1. The possibility of blowouts of plugged wells in the area.
2. That reservoir gas temperature is not so abnormally low that hydrates would form in wellhead equipment under outflow conditions.

Current Experiences

A noteworthy development currently being tested by a number of companies is the use of water filled sands with good structural features as storage reservoirs for natural gas and hydrocarbon liquids. There are 2 such projects under way in Kentucky and at least 2 in Texas. Although nothing, to the writer's knowledge, has been published regarding the methods used and results obtained, it is the writer's understanding that the process shows a great deal of promise. Through a personal communication the writer has learned that a project of this kind was considered unsuccessful because of the loss of stored hydrocarbon fluid. In this instance it is believed that a lack of knowledge of the geological features of the sand resulted in injection wells being drilled too far down on the structure instead of the top. It is believed that the unrecovered fluids were trapped by the shifting water in the reservoir.

Perhaps this process may develop into a possible answer to underground storage for some of those operators not fortunate enough to have depleted or partially depleted gas reservoirs available on their system.

REFERENCES

[1] Ball, Max W., "Underground Gas Storage," Gas Age, June 23, 1949.

[2] Muskat, M., "The Flow of Homogeneous Fluids Through Porous Media," McGraw-Hill Book Co.

Elasticity Modulus Determinations Yield Waterhammer Data

Savings of tons of steel in the construction of new pipe lines throughout the world may be made possible by findings on the "waterhammer" phenomena released by Northwestern University's Technological Institute. The new data should reduce breakdowns, leaks, and damage to oil and gas pipe lines formerly caused by pressure-wave surges.

Professors Lewis H. Kessler and Merrill B. Gamet of Northwestern's Civil Engineering department have designed a "test bomb" for computing the bulk modulus of elasticity of various kinds of crude oils and gasolines from high pressures to low pressures and at temperatures from freezing to boiling. These figures, never before computed for the range of pressures and temperatures found in long pipe lines, will be available to all operators in the U. S. and to engineering organizations.

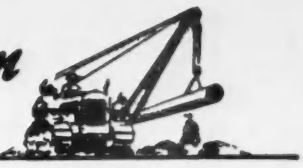
Pressure-wave surges occur in all pipe lines when valves are closed too rapidly, and such surges may destroy valves, spring leaks in pipe joints, or even result in explosions from weak joints. The pressure wave is set up when the valve is closed, and the wave speeds along the fluid in the pipe until it is reflected from the source at the other end. If the pressure wave returns to the closed valve before the moving energy is dissipated, disruptive pressures develop.

The Northwestern engineers have designed equipment, which they call a "test bomb," to determine the bulk modulus of elasticity, a figure necessary to find the speed of the pressure wave in oil and gasoline. They vary the pressure with a series of lead weights, and the temperature is changed by the heated water or ice placed about the test bomb. The equipment is relatively simple.

A series of tests on operating pipe lines accurately verified the conclusions based on the Northwestern data. Engineers now have a dependable basis for the installation of pipe lines and the operation of their valves, for waterhammer surges can be computed and anticipated so that valves may be regulated to offset damaging effects. With the figures now compiled it is possible to design the correct thickness of metal in large pipe lines without wasting steel, a saving that becomes enormous for a line several hundreds of miles long.

The tests made by the Northwestern scientists were part of a research program of the Joint Surge Conference, sponsored by Middle East Pipelines, Ltd., Trans-Arabian Pipe Line Company, and Gulf-Shell Pipe Line.

PIPE LINE *Construction*



By SYLVIA LILLIE
Staff Writer

Projects Announced and Contracts Awarded

Crude Oil Lines

Basrah Petroleum Company plans 72 miles of 12-inch between Zubair and Fao, Iraq. Work is expected to start the end of this year.

Gulf Refining Company plans to build 30 miles of 6-inch gathering line in Kent County to handle production of Caroline Hunt Trust Estate 1, 30 miles north of Gulf's Scurry County gathering system.

Imperial Oil Company, Ltd., plans a 75-mile, 10-inch line from Gretna, to Winnipeg, Manitoba, to supply Winnipeg from Interprovincial Pipe Line Company's line. Imperial will install a pump station at Gretna adjacent to Interprovincial's station.

Iraq Petroleum Company is planning to start in the Fall of 1950 556 miles of 20-, 26-, and 32-inch from Banias, Syria, to Kirkuk, Iraq. From a point out side the Lebanese border the line will follow the route of present lines from Tripoli. Existing pump stations will be greatly enlarged.

Products Lines

Government of Colombia is planning a 121-mile, 6- or 8-inch line from Salmar, on the Magdalena River, to Bogota. The line will be a continuation of the system beginning at the tropical Oil Company refinery at Barranca Bermeja and going to Cantimplora.

Natural Gas Lines

Associated Natural Gas Company has FPC authorization to build 14 miles of 8-inch from Texas Eastern's system near Oran to Sikeston, Mo.; and 21 miles of 6-inch from Sikeston to New Madrid, Mo. Project includes building of gas distribution systems in Sikeston and New Madrid.

Central Kentucky Natural Gas Company has been authorized by FPC to build 41 miles of 20-inch loop from North Means to Foster, Ky., and to install an 880-hp unit in the North Means station.

Champion Savings Corporation has applied to the Alberta, Canada, government for a charter for the construction of a 1000-mile line from Alberta gas fields to Vancouver, B. C.

Cities of Ripley, Booneville, and Baldwyn, Miss., have asked FPC permission to connect their facilities with TGT's system. Project would include a 16-mile, 16-inch line from TGT's line to Ripley, to be built by Ripley; a 23-mile, 6-inch line from Ripley to Booneville, to be built by Booneville; an 11-mile, 4-inch line from Booneville to Baldwyn, to be built by Baldwyn; distribution systems in each city.

Consolidated Natural Gas Corporation plans 26 miles of 16-inch loops in Pennsylvania.

Consumers' Gas Company has application before FPC for the construction of an 85-mile, 20-inch line from Buffalo, N. Y., to Toronto, Ontario.

East Ohio Gas Company has authorization to build 12 miles in two 8-inch storage inlet and outlet lines in Columbiana, Mahoning, and Portage Counties, Ohio.

Jersey Central Power & Light Company has applied to FPC to build 29 miles of 8-inch from South Jersey Gas Company's line at Estelville to Cape May Court House, N. J.

Lion Oil Company plans a 70-mile gathering system in Diamond and Sharon Ridge fields, Scurry County, Texas, and a compressor plant to deliver the gas to the Lone Star Gas Company.

Lone Star Gas Company applied to FPC for permission to build 21 miles of 2- to 4-inch from its 16-inch line near Fort Worth to Keller, Smithfield, Justin, and Roanoke, Texas.

Marine Gathering Company has anannounced plans for a 10-mile, 8-inch line from Pure Oil Company's Rollover field in the Gulf of Mexico to the Louisiana mainline where the gas will be delivered to TGT. Submarine Pipeline Construction Company, Houston, will build in the late Fall.

Madison Utilities Corporation has FPC authority to connect its system to TGT's main line in Carroll County, Ky., with an 8-mile, 4-inch line.

New York State Natural Gas Corporation has asked FPC permission to build 63 miles of 20-inch from Westmoreland County, Penn., to the Pennsylvania-Ohio state line. The East Ohio Gas Company will build a 1-mile connection in the Petersburg, Ohio, area and will receive gas from New York State Natural.

Northern Natural Gas Company has applied to FPC to build an 8-mile lateral from its main line to Jetmore, Ky.

Pacific Northwest Pipeline Corporation has application with FPC for the building of a 2175-mile, 26-inch line from Wharton County, Texas, to Washington State. Also included in the plans are 400 miles of 22-inch and smaller laterals, and 13 compressor stations of 6400 hp each. Estimated to cost $174 million the line would have an initial capacity of 250 Mmcf. The company plans to purchase 100 Mmcf daily from Alberta gas fields, and to supply Vancouver, B. C.

Pennsylvania Gas Company has been granted authority to lay 8 miles of 4-inch and 12 miles of 8-inch between its main line and a connection with TGT's system in Erie County, Penn.

Piedmont Natural Gas Company, Inc., applied to FPC for authority to build 74 miles in 6 laterals from Transcontinental's line to city distribution systems in North and South Carolina.

Prince George's Gas Corporation has made application to construct 20 miles of 22-inch from Atlantic Seaboard's line at Rockville, Md., to its Chillum, Md., compressor station for delivering gas to Washington Gas Light Company and its subsidiaries.

Southeastern Michigan Gas Company has application before FPC to build a 55-mile, 12-inch line from Panhandle's system in Oakland County to Marysville, Mich., for distributing gas in Macomb and St. Clair Counties.

Southern Natural Gas Company has been authorized to build 275 miles of 18-inch from Gwinville, Miss., to Marvyn, Ala.; 221 miles of 16-inch from Marvyn to Aiken, S. C.; and 307 miles of loops and connecting lines in Texas, Louisiana, Mississippi, Alabama, Georgia, and South Carolina. Contract has been let to Sheehan Pipe Line Construction Company, Tulsa, for 180 miles of 18-inch from Gwinville to Selma, Ala., for 32 miles of 16-inch between Elmore station and Mitchell Village, Ala., and for 24 miles of 24-inch loops.

Sun Pipe Line Company plans 57 miles of 8-inch main line and laterals between Clairemont and Colorado City, Texas.

Texas Illinois Natural Gas Pipe Line Company has FPC authorization to build 1331 miles of 26- and 30-inch line from La Gloria field, Texas, to Joliet, Ill. Initial capacity will be 305 Mmcf. The master contract has been given to Fish Pipe Line Construction Corporation, Houston. Midwestern Constructors, Inc., Tulsa, will build Schedule 1—100 miles of 26-inch from La Gloria field to Refugio, Texas; Schedule 11—100 miles of 30-inch from the Mississippi River to Effingham, Ill.; Schedule 12—117 miles of 30-inch from Effingham to Sibley, Ill.; Schedule 13—92 miles of 30-inch from Sibley to Joliet, Ill.

United Gas Pipe Line Company is acquiring right of way for the building of 8 miles of 8-inch, 9 miles of 12-inch, and 68 miles of 16-inch to connect gas fields in Plaquemines Parish, La., to existing pipe line facilities near New Orleans.

United Gas Pipe Line Company has applied to FPC for permission to construct 11 miles of 12-inch between Soso field and Sherron field, Jasper County, Miss., and 51 miles of 12-inch from these fields to the Mississippi Power

Company plant near Meridian, Miss.

United Gas Pipe Line Company has asked FPC approval on the building of a 16-mile, 16-inch line from its Carthage-Sterlington line in Bienville Parish to its Koran gasoline plant site in Webster and Bossier Parishes, La.

Valley Gas Pipe Line Company, Inc., applied to FPC for permission to build a 1440-mile line from Texas and Louisiana to southern Michigan. A 24-inch line would run from Goliad County to the Saratoga field in Hardin County, Texas, where it would be joined by a 24-inch line from the Vermilion Bay area, La., running offshore to Sabine Pass. From Saratoga a 1000-mile, 30-inch line would cross Louisiana, Arkansas, Missouri, Illinois, and Indiana, terminating in southern Michigan. Plans call for 13,250-hp stations at Saratoga and Poplar Bluff, Mo., and for 70,000 hp in additional stations to be installed as needed. Initial capacity would be 330 Mmcf; ultimate capacity 505 Mmcf. If approved, the line will increase by 20 percent the amount of gas going north and east from the Gulf Coast.

Projects Starting

Crude Oil Lines

Humble Pipe Line Company started in July 30 miles of 8-inch from Fort Chadbourne field, Runnels County, to Humble's Ballinger station, Texas. Morrison Constructors, Odessa, Texas, contractor.

Iraq Petroleum Company, Ltd., has started work on its 556-mile line from Kirkuk to the Mediterranean Sea via Haditha, Iraq, and Homs, Syria. From Kirkuk 466 miles will be 30- and 32-inch, and the remaining 90 miles will be 26-inch. Arabian Bechtel Company started right of way and excavation at the Mediterranean end in July.

Magnolia Pipe Line Company is building 50 miles of 12-inch in 4 loops between Colorado City and Hillsboro, Texas. Bishop & Lock Construction Company, Dallas, started in June.

Magnolia Pipe Line Company is at work on 22 miles of 8-inch in Howard and Scurry Counties, Texas. Shanks & Eustace, Alice, Texas, started in June.

Pan-Am Southern Corporation started in July 7 miles of 8-inch loop on a 6-inch line between Schuler and El Dorado, Arkansas.

Products Lines

Great Lakes Pipe Line Company is starting 77 miles of 12-inch from Sioux City, Iowa, to Sioux Falls, S. D.

Tuscarora Oil Company, Ltd., is replacing its 360-mile line between Linden, N. J., and Pittsburgh with 10- and 12-inch pipe. Four large pumping stations will replace 9 old ones, and the present capacity of 25,000 will be raised to 45,000 with a potential of 80,000. Pipeline Construction & Drilling Company, Camp Hill, Penn., is at work on 50 miles of 10-inch in the vicinity of Ebensburg, Penn.

Natural Gas Lines

Acme Natural Gas Company expects to start work in August on 25 miles of 6-, 8-, and 10-inch line in the vicinity of Butler, Penn. Williams-Austin Company, Pittsburgh, will do the construction if FPC approval is given.

Canadian River Gas Company is building 60 miles of 4- through 16-inch line northwest of Amarillo, Texas. Z. Jack Graham, Amarillo, contractor.

Commonwealth Natural Gas Corporation started in July 189 miles of 12- and 18-inch main line from Virginia Gas Transmission Corporation's 20-inch line in Greene County to Richmond, Va.; and 228 miles of 8-, 12-, and 18-inch laterals in Virginia. Ray L. Smith & Son., Inc., El Dorado, Kansas, is contractor for both projects.

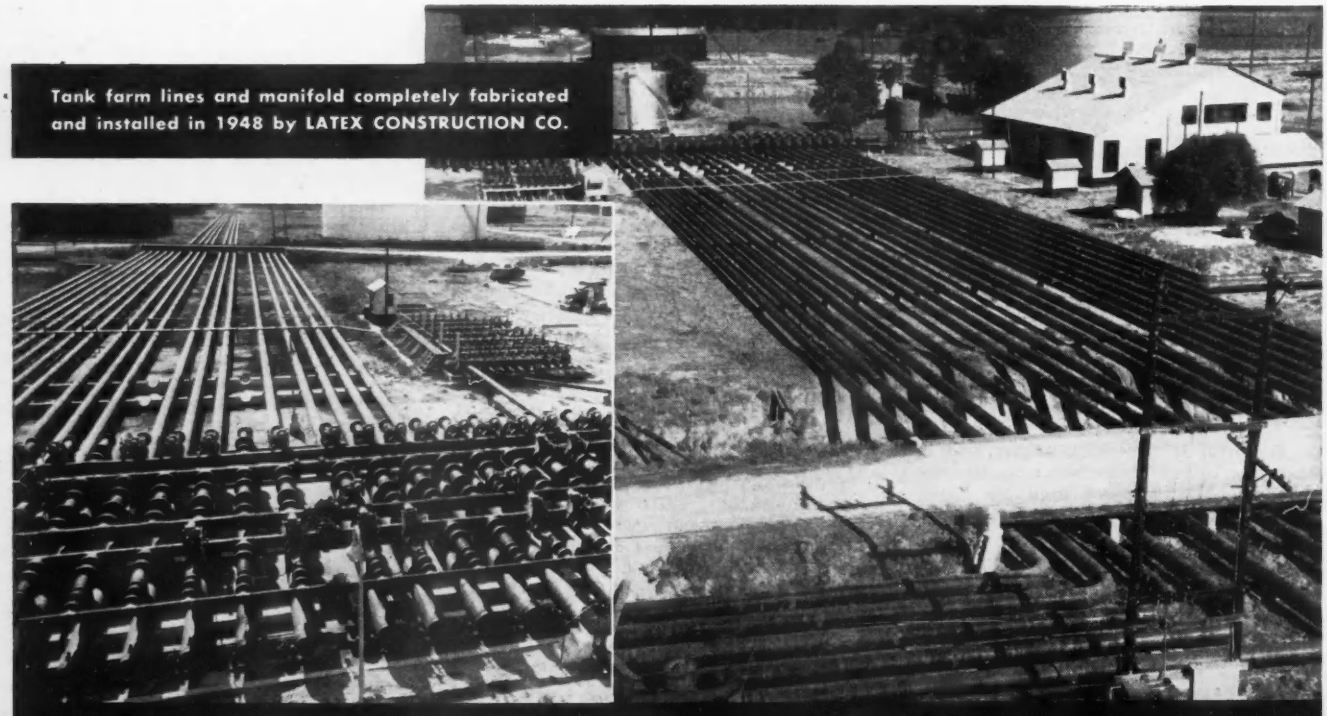
Northern Natural Gas Company is building 85 miles of 4- through 12-inch in the vicinity of Ulysses, Hugoton, and Garden City, Kansas. Reese Bros. Construction Company, Hugoton, started in June.

Northern Natural Gas Company started in June a 37-mile, 10-inch line between Ames and Marshalltown, Iowa. Knupp Construction Company, Inc., Great Bend, Kansas, contractor.

Tennessee Gas Transmission Company started in June 26 miles of 12-inch from Starr County to Hidalgo County, Texas. Sheppard-Geiger Construction Company, Corpus Christi, contractor.

Tennessee Gas Transmission Corporation is at work on 95 miles of 20-inch from its main line in Natchitoches to Kinder, and 75 miles of 16-inch from Kinder to Bayou Sale, La. Latex Construction Company, Houston, started both lines in July.

Tennessee Gas Transmission Corporation started in early July a 32-mile,



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General Contractors

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Laurence H. Favrot — Geo. A. Peterkin — J. W. Sharman — R. P. Gregory

12-inch lateral from Slaughters, Ky., to Evansville, Ind. J. Ray McDermott & Company, Inc., Harvey, La., contractor.

Transcontinental Gas Pipe Line Corporation will start in August 44 miles of 26-inch from the junction of State Highway 113 and U. S. Highway 77 in Refugio County to Edna, and 30 miles of 26-inch from Edna to the Harris-Fort Bend County line, Texas. Oklahoma Contracting Corporation, Dallas, contractor.

Transcontinental Gas Pipe Line Corporation is building 40 miles of 6- and 8-inch sales laterals in Pennsylvania. Northeastern Construction Company, Harrisburg, Penn., contractor.

Transcontinental Gas Pipe Line Corporation is building a 20-mile, 20-inch sales lateral from its main line to Marcus Hook, Penn. John Meehan & Son, Philadelphia, and Conduit and Foundation Corporation started in July.

Trunkline Gas Supply Company will start work in August on its 740-mile line from Longville, La., to Tuscola, Ill., with supply laterals to Texas and Louisiana Gulf Coast fields. Houston Contracting Company will build 176 miles of 26-inch from Longville to Darnell, La., and a 59-mile, 10- and 16-inch lateral from Longville to southwest Louisiana. Anderson Brothers Corporation, Houston, has the contract for 180 miles of 26-inch from Darnell to Senatobia, Miss., and a 217-mile, 24-inch lateral from Garwood, Texas, to Longville. R. H. Fulton & Company, Lubbock, Texas, will build 184 miles of 26-inch from Senatobia to Joppa, Ill., and a 262-mile, 20-inch lateral from McAllen to Altair, Texas. E. J. Mahoney Contracting Company, Mt. Pleasant, Mich., will lay 186 miles of 26-inch from Joppa to Tuscola.

United Gas Pipe Line Company will soon begin a 23-mile, 16-inch line from Mud Lake field, Cameron Parish, La., to Gulf Refining Company's plant at Port Arthur, Texas.

Projects Completed

Crude Oil Lines

Buckeye Pipe Line Company completed in early July 23 miles of 8-inch between Sylvania, Ohio, and Monroe, Mich. Bills & Troth Construction Company, Tulsa, contractor.

Mid-Valley Pipeline Company finished 2 spreads of its 22-inch Texas-Ohio line. Sections 4B and 5A—111 miles from Henderson to Clarksville, Tenn., and Section 7—120 miles from Hebron, Ky., to Lima, Ohio, were completed in July by Eastern Construction Company, Inc., Dallas.

Texas Pipe Line Company completed in July a 42-mile, 12-inch line from Patoka to Clay City, Illinois. L. R. Young Construction Company, Olney, Ill., contractor.

Products Lines

Salt Lake Pipe Line Company expects to complete in August its 240-mile line from Boise, Idaho, to Pasco, Wash. Morrison-Knudsen Company, Inc., Macco Corporation, and Bechtel Corporation, San Francisco, are building 120 miles of 8-inch from Boise to Baker, Ore., and Pacific Pipeline & Engineers, Ltd., San Francisco, are working on 120 miles of 6-inch from Baker to Pasco.

Natural Gas Lines

East Tennessee Natural Gas Company completed an 18-mile line from Oak Ridge to Knoxville, Tenn. This is a continuation of the 172-mile line from TGT's system at Lobelville to Oak Ridge, completed in 1949.

Harrisburg Gas Company completed in July 20 miles of 8-inch from Manufacturers Light & Heat Company's line at Maytown to Steelton, Penn. Northeastern Construction Company, Harrisburg, Penn., contractor.

Michigan-Wisconsin Pipe Line Company completed in July 197 miles of 8- to 14-inch main line between Milwaukee and Green Bay with laterals to Fond du Lac and Sheboygan, Wis. G. G. Griffis Construction Company, Tulsa, contractor.

Ohio Fuel Gas Company completed in July 3 short lines in Ohio. Somerville Construction Company, Ada, Mich., built a 20-mile, 20-inch line from Mt. Gilead to Galion, and a 12-mile, 16-inch line from Berlinville to South Amherst. Ohio Pipe Line Construction Company, Granville, Ohio, put down a 10-mile, 16-inch line between Mansfield and Pavonia.

Sun Oil Company, Natural Gas Department completed in July 30 miles of 3- through 8-inch gathering system in Starr County, Texas. Shanks & Eustace, Alice, Texas, contractor.

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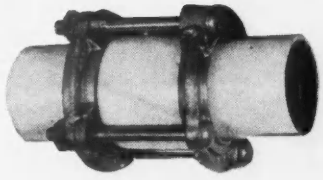

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Styles 4 and 41, for repairing and preventing leaks through threads of screw collars.

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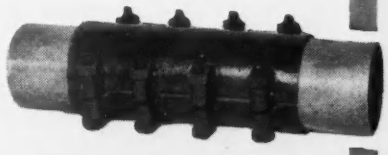
Style 77B, for repairing small leaks and holes in the run of pipe.



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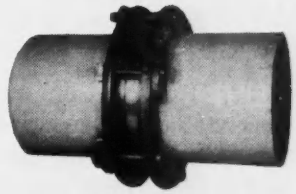
Style 79B, for repairing pitholes and longitudinal splits in pipe.



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Style 55, for repairing circumferential weld leaks.

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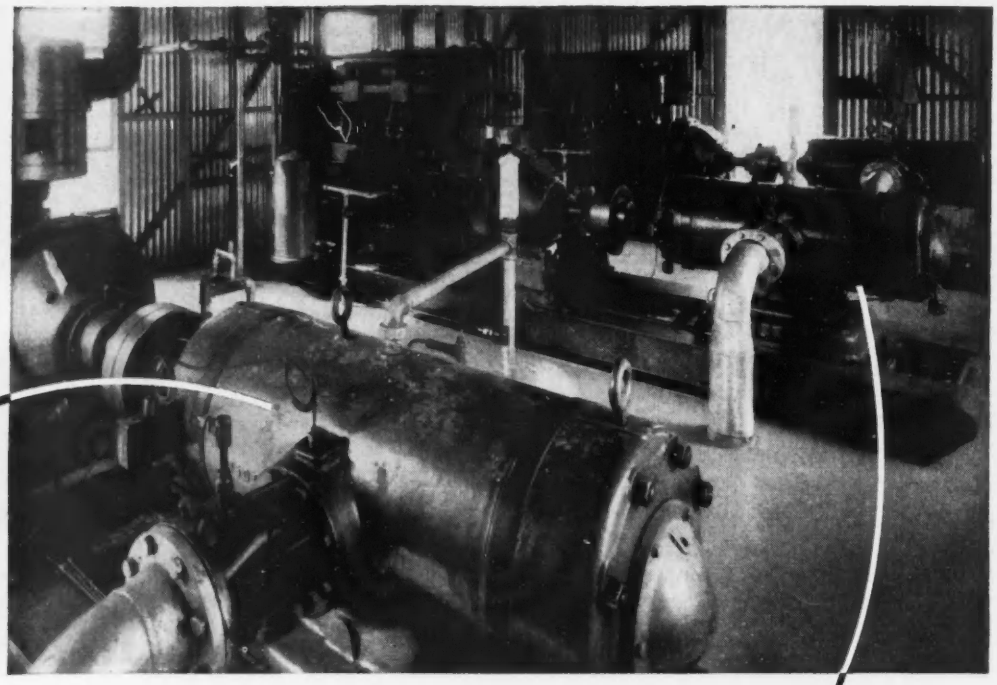

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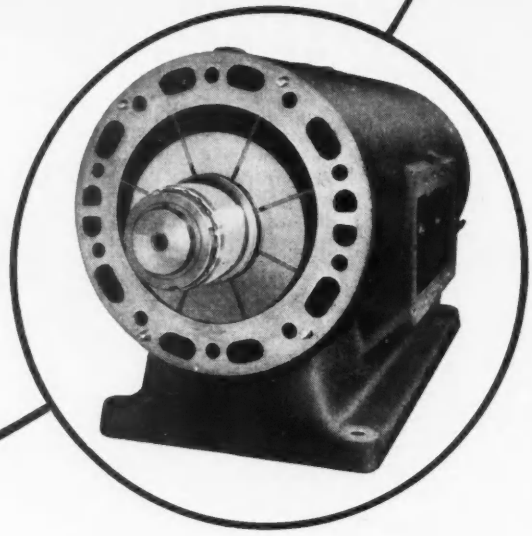

Fuller Rotary Compressors are about the most faithful workers you can put on your payroll. You can spot them where you need them along your gathering lines . . . and always be sure they'll be on the job day after day, week after week.

Fuller Rotary Compressors are built to be dependable and economical in operation. They have but few moving parts . . . the rotor, bearings and blades. That means infrequent inspection, and minimum maintenance. Because blades automatically compensate for wear, full capacity is maintained for the life of the machine. Every detail in Fuller Compressors is engineered for one purpose . . . to give a life-time of new machine efficiency.

Fuller engineers will be glad to work with you for the proper application of Fuller Compressors to gathering lines or general booster requirements. You'll be taking a long step toward more economical, efficient operation if you call them in today . . . or write for Bulletin C-5, describing and illustrating in detail Fuller Rotary Compressors.

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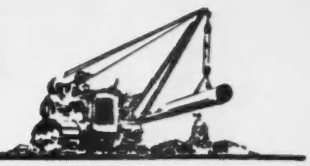
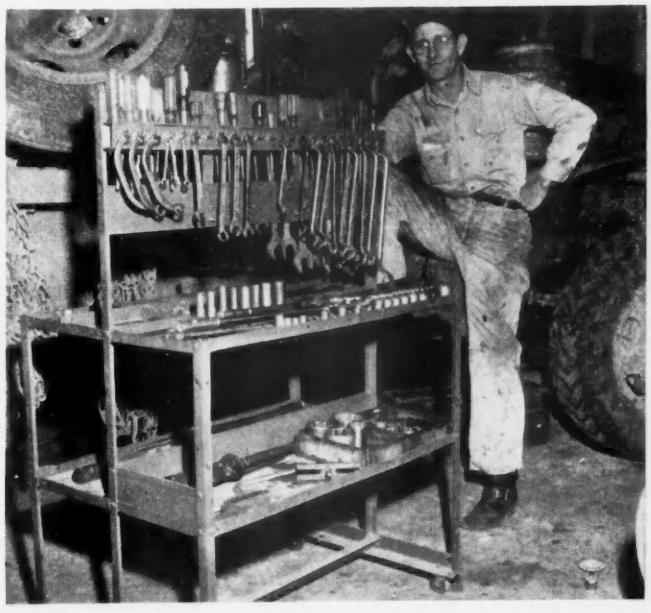
PIPE LINE HINTS



$10 is paid for each illustrated acceptable contribution. Mail to The Editor, WORLD OIL, P. O. Box 2608, Houston 1, Texas

HOW TO—Keep Shop Tools at Hand



A tool rack with a place for every tool, which makes it easy to put everything in its place, may be constructed by the shop mechanic in his spare time. It consists of two main shelves for socket wrenches, with the smaller ones on the top shelf and the larger ones on the bottom. All open end wrenches and box wrenches are hung conveniently from a rack above the center of the top shelf. Screw drivers are placed in holes through a piece of channel iron on which the hooks for the box and open end wrenches are welded.

Made of sheets of scrap metal and angle iron, the angle iron is drilled in several places to make the shelves convenient for several sizes of tools. The lower shelf is divided in the middle and has a wall on one end. The other end and front are left open to provide easy access to the tools. The entire assembly is mounted on casters and may be wheeled right up to the job. No space is provided for a work bench. The tools are never covered with parts of machinery and are always readily accessible.

HOW TO—Support Small Line Span

Where semi-permanent lines are placed across creek beds, a simple span may be formed with used drilling cables and 2 x 4 lumber. After the standards are placed on either side of the stream, the line is laid on the ground and the dog legs on the ends welded in place. Three pieces of 1-inch drilling cables are then strung along the line and fastened to sleeves on the pipe line with turnbuckles.

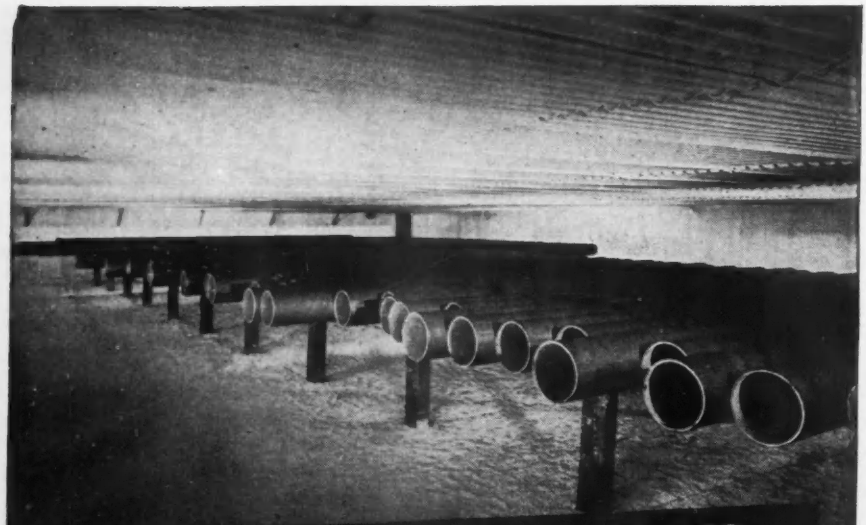
Raising the line up on blocks 4 feet high, the 2 x 4's are wedged in between the 3 cables at right angles as shown. Braces are then spiked between the 2 x 4's to hold them in position. The turnbuckles are then taken up so that the cables are in tension and the pipe in compression. The entire assembly is then raised up on the standards and the turnbuckles are adjusted to hold the pipe in a true line. The lower cable holds the pipe up and the other two cables stiffen the pipe against lateral motion due to wind and vibration.

This crossing has been in service more than 8 years and no signs of deterioration are evident.

HOW TO—Power Two Pumps By Differential Gear

This unusual hookup provides the driving power for 2 centrifugal crude oil pumps from a single gas-powered engine. Power is transmitted through a differential gear similar to that of a truck or automobile. The engine, centrifugal pumps and differential are mounted on a large rectangular skid made from I-beams. The pump-differential combination is separately mounted on a smaller frame which mounts at right angles to the runners of the larger base skid.

The movement of crude oil from a lease can be doubled by such a piece of equipment. Each pump is so connected that it can be operated singly, in parallel, or in series. Such a manifold system makes the unit flexible enough to handle a variety of pumping jobs.



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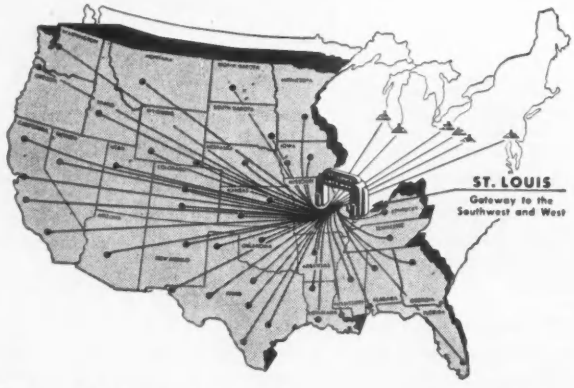

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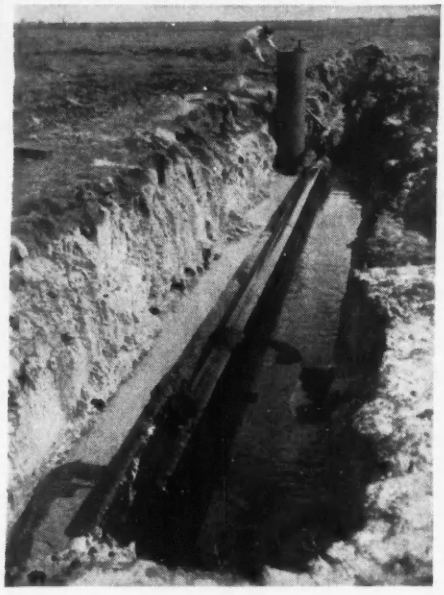
HOW TO—
Build Condensate Collection System

On leases where the gas is bought at a temperature higher than the temperature of the ground, condensate will collect in the lines on the downstream sides of the meters. One company makes it a practice to bury 2 joints of 16-inch pipe, which hold enough condensate for a truck load. All liquids are thus saved and transferred to stock at the dehydrating plant.

As shown, the drip is placed below the level of the gas line and the inlet and outlet are placed on top of the drip,



so that the gas must travel downward through the 16-inch pipe and upward through the outlet. This causes all of the entrained liquids to be released by the gas while passing through the drip. The downstream end of the drip is a few inches lower than the upstream side and a 2-inch connection is placed in the bottom of that end. A 2-inch valve is placed on the connection, then it is swaged down to 1 inch for the blow line. The 1-inch riser and the drip fork used to work the 2-inch valve are incased in a section of pipe and the bleeder line is put at a convenient height for the hose connection on the truck. No burning pit is necessary as all of the condensate is hauled into the plant instead of being burned.

This simple method of collecting condensate in gas lines prevents waste of the liquid, and effects a saving which makes the cost of the gathering installation economical.

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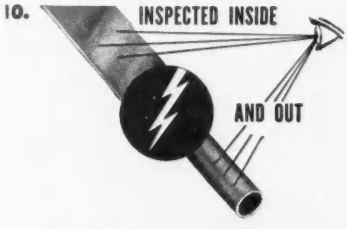
10. 

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● During construction of this 12¾" gasoline line out of Tulsa, a complicated cross-over bend had to be made near Bartlesville, Oklahoma.

Here again, the *high ductility steel* found in every length of Republic Electric Weld Line Pipe proved its value in speeding field bends. This section of the line took the bend in stride and hurried on toward completion.

Easy bending, high ductility steel is but one of the "plus" features this up-to-date line pipe offers you. It's out in front on all 10 counts listed here.

They're the reasons why more than 55,000 miles of Republic Electric Weld Line Pipe have been laid during the past twenty-one years, carrying crudes, gasoline, natural gas and by-products.

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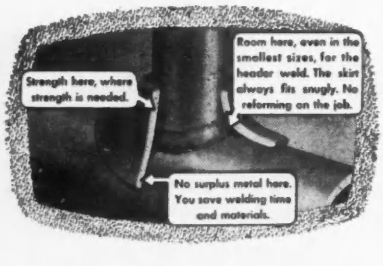
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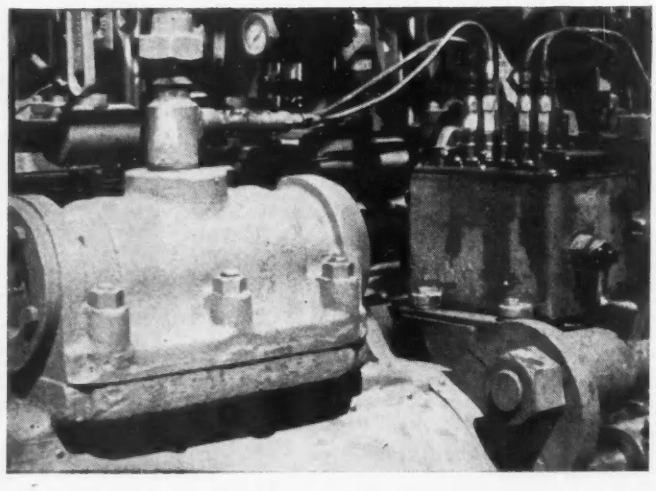
HOW TO—Power Lubricating System

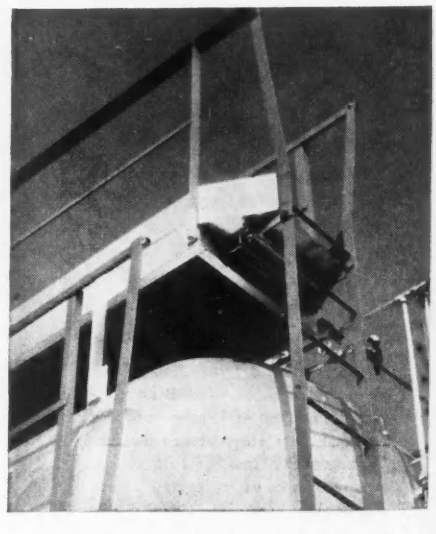


Because an emulsion is not formed when lubricating reciprocating pumps operating on high pressure gas, as happens when either saturated or high temperature steam is supplied, the problem of distributing the oil over the cylinder and piston surfaces has been rather difficult. If the oil is introduced into the line at the intake of the power end of the pump, the lubricant follows the line of least resistance and spills slowly over only a portion of the inside of the cylinder, leaving a section oiled too much and another section running almost dry. This problem has been solved by using a "quill" distributor.

It is a small diameter line, cut lengthwise in half and the sides cut with serrations. This pipe nipple is welded to a larger line with threads to pass tightly, as any other connection, into a bushing so that the serrations are on the upper side of both lips of the "quill," which is cut long enough to almost touch the opposite side of the pump gas line fitting, or pipe.

As the lubricant is pumped to the power cylinder, it collects in the trough of the quill until full, when it spills through the depressions between the saw-teeth. The force of the gas passing over the quill breaks the oil into finely divided particles which are suspended in the gas and reach all parts of the bearing, or sliding surfaces. Frequent inspections of the interior of power cylinders show that adequate lubrication is supplied to all parts of the connecting surfaces by means of this device.

HOW TO—Add Toe-Board to Catwalk



Catwalks above horizontal storage tanks can be made safe with safety treads and handrails as standard equipment. One plant operator went a step further by installing toe-boards so a man cannot push a leg through beneath the bottom rail and suffer an injury.

Wide strips of tread steel, cut to desired length and width for utility and appearance are bolted snugly to the inside of all handrail risers. At the landing platform where the top of the ladder is attached to the catwalk, additional pieces of tread stock, of the same width as the top section of the side plates, are welded to the end riser of the guard rail and to the side of the ladder side piece.

With this type of additional protection, there is less danger of an employe slipping and falling through the guard rails, and he has a feeling of security while working on top of the tank.

Corrosion Control in the Lake Maracaibo Oil Fields

By JOHN H. ZAUNER

Corrosion Engineer, Creole Petroleum Corporation, Venezuela

THE Lake Maracaibo basin is justly famous as one of the great oil producing regions of the world. The fields operated by Creole Petroleum Corporation have long been unique in that the wells are located in the lake itself, with all of the operations involved in finding, producing, and moving the oil carried on as far as 12 miles offshore, in water up to 90 feet deep. Many new techniques have been developed in the course of opening up the fields of La Rosa, Punta Benitez, Tia Juana, Lagunillas, and Bachaquero, particularly in recent years as hundreds of wells have been drilled farther and farther from the bases of operations on shore. These fields have been highly productive, not only of petroleum, but of problems as well. One of the most challenging of these problems has been the corrosion caused by the lake water.

The lake is neither fresh nor salt. Numerous rivers, some quite large, flow into it but it is open to the sea at the northern end. At present the composition of the water in the northeastern portion where oil is being produced approximates 1 part seawater diluted with 14 parts of soft, fresh water. It is warm—below the surface the water temperature remains at 88° F. year-round. It is abundantly supplied with fish and other marine organisms, as well as large quantities of both living and dead vegetable matter. Although there is little tide, the lake does get rough on occasion and typically there is a considerable amount of wave action. Consequently, the Lake Maracaibo ambient consists of warm, brackish water highly oxygenated at the surface. It is virtually anaerobic on bottom and nearly as electrically conductive as seawater, yet lacking the lime content which tends to form dense, adherent corrosion products in seawater and in hard fresh waters. The corrosion rate of unprotected mild steel in this water is about 6 times greater than in average seawater.

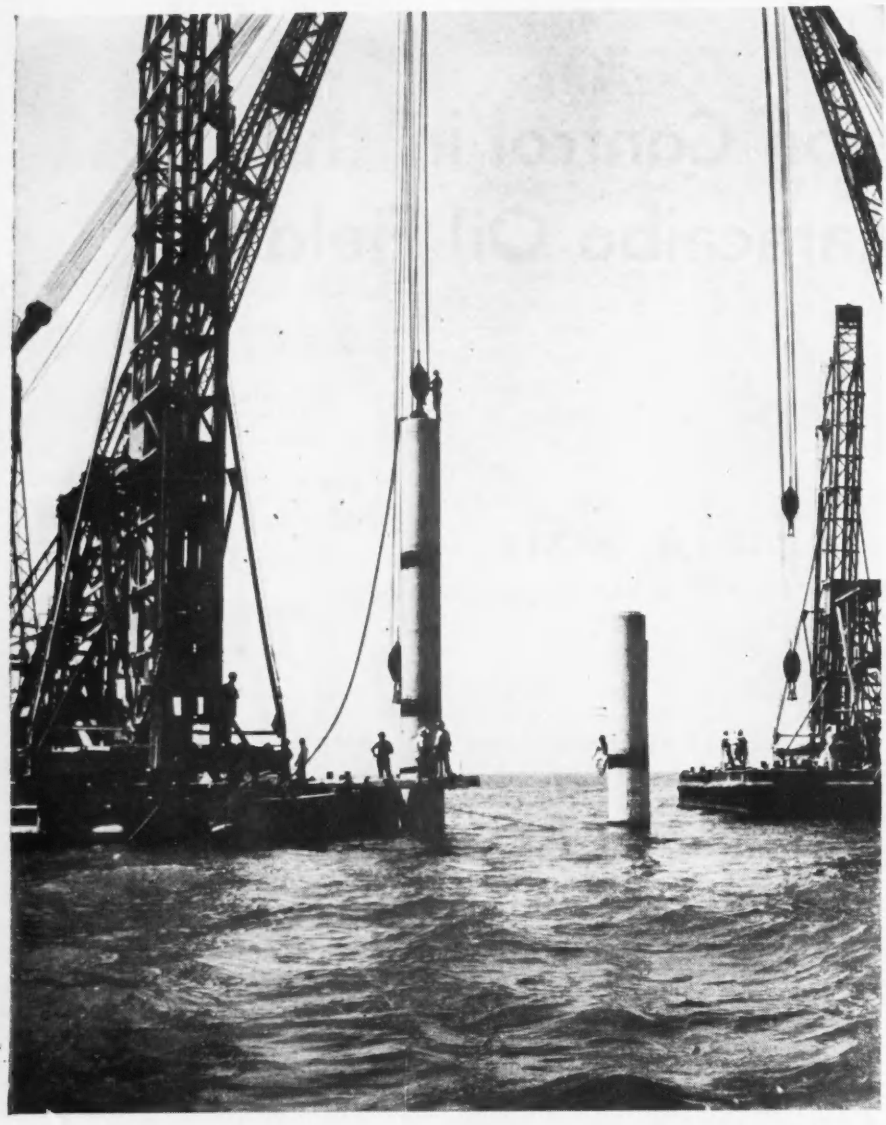
In this corrosive environment Creole must drill wells, and to produce these wells, lay and maintain gathering lines. Lines laid to date total more than 1300 miles, of which about 820 miles remain in service. The total investment in these gathering lines approaches $10 million, and recent replacement costs are generally higher than the original installation costs of previous years.

The general nature of this large gathering system is as follows: each well is produced through a flow line, commonly 4½-inch outside diameter, which lies on the lake bottom and connects the well to a flow station (tank battery). Most flow lines are between 1000 and 4000 feet long, and lie in water from 20 to 60 feet deep. Flow stations are connected with each other and with tank farms on shore by a network of pump and gravity lines ranging from 6- to 16-inch, and typically each main gathering line is 1 to 2 miles long. Superimposed on this oil gathering system, which is in itself rather complex, are many additional pipe lines for the movement of gas, sweet water, and lake water, as well as a system of submarine cables for carrying electric power to the flow stations and pumping wells. The whole network of structures on lake bottom, including old lines abandoned in place, comprises about 1500 miles of pipe and cable in an area of 100 square miles.

A TIMELY report on corrosion problems in one of the most unusual oil producing areas of the world, this article discusses one company's successful efforts in combating the destructive parasites of Lake Maracaibo. Marine organisms, particularly the destructive teredo, are impartial in their tastes — attacking steel, aluminum, wood, rubber and synthetic compounds with equal vigor.

In addition to the naturally high corrosion rate of steel in this water there are such complicating factors as the numerous contacts, both above and below water, between old pipe and new pipe and between steel pipe and copper-armored cable. The tendency is always for the new pipe to be corroded more rapidly as the result of these contacts, and for the copper armor wire, (and, to a lesser extent, the oldest pipe) to be protected at the expense of the new steel.

A good deal of coated pipe was laid in the lake during the thirties, and this coating, although far from perfect, did extend the useful life of gathering lines. But all of the pipe laid in the last 9 years—the major part of the footage now in service—has been laid bare. This bare pipe starts to corrode the instant it is placed in the water, with a high average rate, and with many deep pits which cause early penetration. The vertical sections (risers) at each end of each line are exposed to the highly oxygenated surface water, and together with lower part of the riser and the nearby portion of the line constitute an example of the phenomenon known as a "differential aeration cell," a potent source of corrosion. Pipe on bottom is in a favorable environment for sulfate-reducing



Concrete piling being set in shallow waters of Lake Maracaibo for well foundations. Concrete apparently is not affected by the destructive marine organisms.

Laying a 16-inch trunk line to shore from apex of field gathering system in the lake.

bacteria. These organisms require sulfates, organic matter, mild temperature, and a nearly neutral pH, and the bottom of Lake Maracaibo obliges them in all respects. These bacteria, in turn, carry on a complex chemical reaction on the surface of the pipe, resulting in a constant penetration of the metal, with little or no formation of the hard scales and rusts which ordinarily would slow down the corrosion process after a time.

Service Records

The service records of hundreds of gathering lines have been carefully analyzed, to establish the average corrosion rate of steel pipe under these unfavorable conditions. Each size and weight of pipe has a different life expectancy, with the extra-heavy pipe lasting longer than the standard weight. To take one size as an example, 4½-inch O.D., 12.67 pounds per foot, line pipe, will start to leak, on the average, after only 34 months in the lake. The length of time such a line can be kept in service depends on several factors. Typically the leaks tend to cluster in certain sections of the line. One to 3 years after the first leak appears, it is usual for the leak frequency to reach such a high rate that replacement of at least part of the line is unavoidable. The leaks are stopped by the application of a repair clamp, which must be placed by a diver. When so many clamps have been used on a given section that there is no room for more clamps, or when new leaks occur each day, it is no longer practical to continue this type repair work. Sometimes it is profitable to replace the worst section of the line, and by this means complete replacement of a few bare flow lines has been delayed for as long as 9 years. But if the line is relatively short, or if it is in deep water, it is usually more economical to abandon the line and to lay a complete replacement. At present, 4½-inch bare flow lines require replacement every 5 years, and about half of all the pipe laid in the lake each year is for replacement of lines or portions of lines abandoned because they are corroded to a condition unserviceable and irreparable.

Corrosion on this scale is believed to be much worse than anything experienced in soil or in water anywhere else in the world. The direct losses attributable to the corrosion of the Lake Maracaibo oil gathering system amount to more than $1 million annually.

To meet the challenge presented by this staggering rate of loss, Creole 3 years ago instituted a Corrosion Control Program. For the first 2 years, activities were mainly confined to gathering data, setting up systems of reports and records, and making tests and measure-

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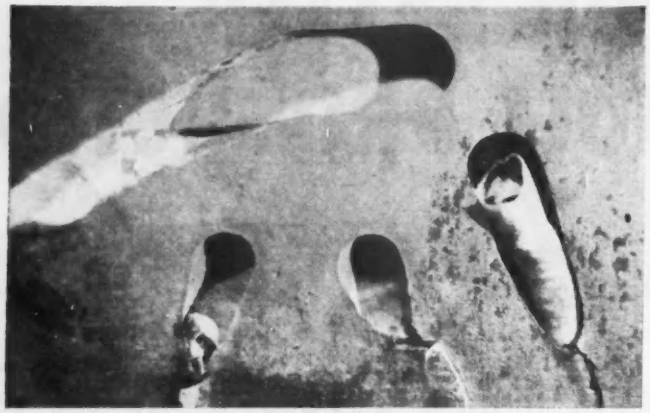
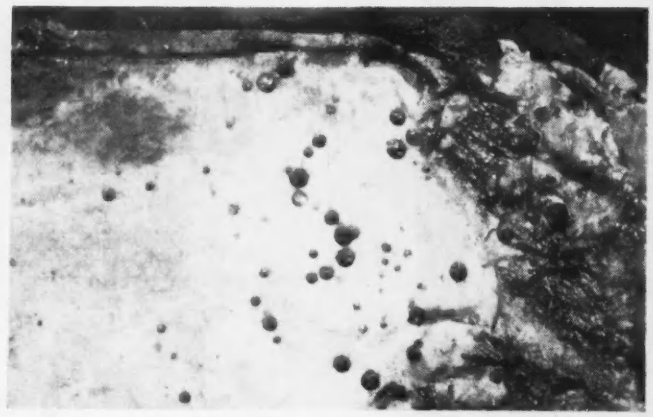


This view shows the action of Lake Maracaibo's "terrible teredo" on natural rubber.



Pipe line insulation material (polyethylene) shows effect of teredoes after 15 months.

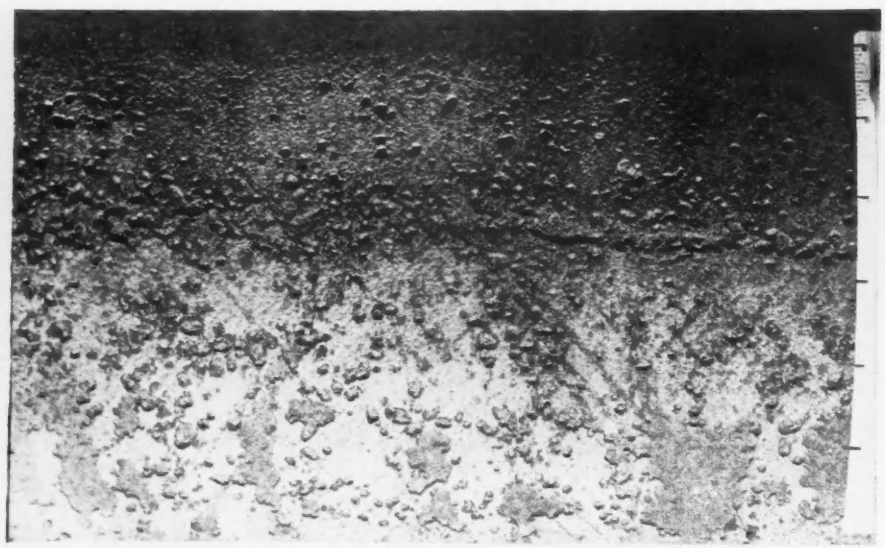
ments. During 1949 the program moved into the engineering phase, and progress is now being made in extending the service life of gathering lines. Much remains to be done.

Insulating Flanges

The first large-scale control measure introduced was insulating flanges. The use of special gaskets between the flange halves, in conjunction with insulating sleeves and washers on the flange bolts, stops the flow of current at that point. By this means the galvanic corrosion of new steel because of contact with old piping and with copper armor wires can be drastically reduced. All new lines are installed with an insulating flange at each end, and excellent progress has been made in insulating old lines. Many such installations have been tested, and it has been found that each insulating flange is cutting off the flow of destructive currents which range in magnitude from a fraction of an ampere to 10 amperes. One ampere flowing for one year removes 26 pounds formly distributed over the line, but in general represents deep pitting on risers and on the nearby section of the line. When all the lines in the lake are so insulated, the saving in direct losses attributable to corrosion will amount to at least $100,000 per year.

A second approach to the problem of reducing corrosion costs on the lines already in service is the use of magnesium anodes. When coupled to a large steel structure such as a pipe line, a standard 51-pound cylinder of nearly pure magnesium is dissolved at a rate indicating complete consumption in 3 to 8 years. In the process of dissolving, the magnesium drains current from the steel to which it is coupled, and this current acts to retard corrosion of the steel structure. In the case of an average flow line, the current is sufficient to provide complete protection within a 15-foot radius. The cost of a single anode is about half as much as the installed cost of the repair clamp itself. Therefore, if only one additional leak is prevented, the anode installation represents a 100 percent profit. Anodes are now being installed in conjunction with pipe repair clamps on old leaky lines as well as on new risers and on new pipe used to repair old lines.

A start has been made on the project of putting the gathering system under cathodic protection. Cathodic protection is a method of corrosion control which has given satisfactory results in many parts of the world and has been extensively applied to buried pipe lines, particularly, in the U. S. In Lake Maracaibo there are some unique problems to solve in the design of such installations. Creole's tests, confirmed by model studies conducted in the laboratories of The Carter Oil Company, indicate that it is practically impossible to protect the full length of bare flow lines and main gathering lines which converge to form a radial pattern at each flow station. The area of complete protection on bare pipe extends hardly beyond the flow station risers when a single anode is centrally located, and the use of multiple anodes is excessively costly. However, cathodic protection is being installed on the newer flow stations because studies indicate a reasonable pay-out even with bare pipe. When coated pipe is laid to replace these lines it is under protection from the day it is laid and it should be possible to keep well-coated lines in service with cathodic protection for the remaining life of the concession.



Typical corrosion of bare pipe line after eight months service on the bottom of the lake. Note scale of inches to the right, indicating extent of corrosion. Bottom of photo shows corrosion of pipe in mud and upper half shows corrosion of pipe in the water.

Coating Lines

The coating of new and replacement lines is obviously the largest phase of the corrosion control program yet to be initiated. It represents a more difficult un-

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Large power barge used by Creole on Lake Maracaibo. These vessels have corrosion problems also.

dertaking for Creole than for almost any other oil company because of several complications inherent in Lake Maracaibo operations. In the first place, the coating used must be tough enough to be handled on the barges which transport and lay gathering lines. Second, the coating must be resistant to plastic flow to an extent that it will not be pushed away from the underside of the pipe as it rests on bottom in the warm water. For reasons of cost, the coating selected for use in Venezuela should be made, insofar as as is possible, from locally available materials. A special requirement for Lake Maracaibo is that the coating should not appeal to the appetites of the marine organisms that thrive there. So far, teredoes (and, in some cases, other organisms such as barnacles and fish) have been found to penetrate not only wood—which is to be expected—but such diverse materials as asphalt and coal tar enamels, asphalt mastic, natural rubber, neoprene, polyethylene, vinyl insulation materials, and even aluminum foil. Of course, if no suitable material absolutely resistant to attack can be found, a coating will be used which represents the best compromise with all requirements, and cathodic protection will be relied upon to prevent loss of steel where the coating is destroyed by marine organisms. Because of the high cost of labor in Venezuela, pipe coatings must be applied by means of well-engineered machinery, automatic in operation and set up in accordance with efficient material flow lay-outs, in order to keep direct labor and supervision costs at minimum levels. All of these requirements for a coating are being studied, and although a 100 percent solution is not likely, sufficient progress is being made that the inception of a pipe coating program should not be long delayed.

Although the gathering lines represent the largest part of the corrosion problem in Lake Maracaibo, they by no means constitute the whole problem. All of the wells drilled in the lake must be protected against corrosion of the surface string of casing, which has been particularly bad at the water line and at the mud line on lake bottom. Several years ago, a simple but effective solution to this problem was developed. An outer protector pipe is placed over the surface string, pushed down into the mud and cut off to extend just above the high water mark. The annulus is filled with cement, and the protector pipe becomes in effect an expandable form. Even after it is corroded away, the cement remains to provide excellent protection for the casing.

The well foundations in shallow water and in moderate depths provide no corrosion problem because the concrete piles stand up well, and it appears that they will endure for the life of the concession. In deep water, however, where caissons are used, a major part of the weight used to push each caisson down comes from the lake water with which it is filled. To retard corrosion of the steel lining, the addition of caustic soda is effective and inexpensive. Long-term experiments are in progress to evaluate substitution of other chemicals easier to handle.

Protecting Marine Craft

To drill these wells on the lake and to produce the oil requires the use of hundreds of marine craft, ranging from small dories to extra large barges, all with steel hulls. Various paints and hot-applied coatings are used, but for additional protection near the propeller and shaft, the conventional zinc plates used on sea-going vessels have been supplanted by magnesium discs. Over a year's experience with magnesium for this application has proved it to be far more effective than zinc, at least in Lake Maracaibo.

The corrosion problem in Lake Maracaibo is neither new nor unique. It is, however, on a large scale because of the scope of Creole's operations on the lake—500,000 barrels daily production—and, further, the corrosion problem is intensified as compared with other oil fields, because of the peculiarities of the Lake Maracaibo ambient. There is no magic formula by which this ambient can be changed. In the foreseeable future, to place bare steel in Lake Maracaibo will be comparable to bathing it in a mild pickling solution. At present, to place coated pipe in the lake is equivalent to operating a snack bar for teredoes and barnacles. But concentrated study of the characteristics of the ambient and of ways of adapting known techniques to meet local conditions is beginning to pay off. Control of corrosion is the goal, and $1 million per year is the stake. Soon perhaps, the title of "World's Worst Corrosion Problem" can be relinquished by the Lake Maracaibo oil fields.

About the Author

JOHN H. ZAUNER has been corrosion engineer for Creole Petroleum Corporation since 1946. Located in the center of Bolivar Coastal field operations at La Salina (Estado Zulia), Venezuela, he is responsible for all research, development, testing and engineering pertaining to the control of corrosion, not only for the Lake Maracaibo area, but for Creole's country-wide operations in Venezuela. Before going to Venezuela he was in charge of research and development contracts in the U. S. Navy, Bureau of Ordnance. During the war he was senior engineer with the Johns Hopkins University of Applied Physics Laboratory in Silver Springs, Md.

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PAKISTAN Opens To American Oil Men

AMERICAN oil companies have been invited to participate in the petroleum development of Pakistan in connection with that country's intensified search for oil. Pakistan's premier, Liaquat Ali Khan, on his recent visit to the U. S., said the technical help of the U. S. industry will be sought in exploration and development of oil resources in the Patharias Forest area, part of the Chittagong Hill tracts of East Bengal.

British assistance also will be enlisted through the huge Burmah Oil Company which is moving $600,000 worth of oil prospecting equipment from Karachi to Chittagong. The equipment is en route to the region by boat, and includes 1200 tons of material—one complete drilling rig, tractors, water-pumping machinery, pipe, machine tools, heavy transport and numerous accessories. The drilling equipment will be used by Burmah Oil Company in renewal of its operations in East Pakistan, the first since exploration activities were suspended pending settlement of the boundary dispute between Pakistan and Bharat.

The Pakistan program includes construction of a refinery which is planned with the help of American companies on a short-term lease basis.

Oil interest in Pakistan goes back to the late 1880's when seepages were noted in the western part of the country, especially at Khattan in Baluchistan, southeast of Quetta, where several wells were drilled. These early operations resulted in a production of only about 20,000 barrels of oil, and the venture was abandoned as a failure. Subsequently 5 wells were drilled at Sadkal in the Punjab, at Chharat Kundal and other locations but no commercial discovery was reported.

The Burmah Oil Company in 1916 drilled a test well at Chanragup on the Mekran coast of southern Baluchistan to a depth of 2660 feet, but abandoned it as a dry hole. Meanwhile the Attock Oil Company of Rawalpindi was also prospecting. This firm drilled a number of wells in the West Punjab south of the Salt Range leading eventually to the discovery of 4 oil fields in the Potwar region, the center of Pakistan's petroleum industry today.

Burmah Oil extended its operations in Sind and in 1925 drilled a well at Khairpur and another at Drigh Road, near Karachi, in 1939. Both were dry. The company widened its activity to the Meyal area and drilled 2 dry holes there, then 3 at Khabakki and at Chakwal, the latter in 1947. No success was achieved despite the fact that the Chakwal test went to a depth of 8740 feet. Burmah discovered oil in the Patharias Forest region in 1933 but the well was capped and the field was not developed. Its potential production has been estimated at 10,000 barrels daily.

Lakhra, a deep test in Sind near Hyderabad, was spudded in in 1948 and was drilled to 12,666 feet. It encountered gas sands but no oil.

On July 1, 1949, a notable oil discovery was made by Burmah Oil Company in its Chakwal 2 in the West Punjab. Oil was found at 8214 feet beneath a 100-foot layer of limestone.

The Chakwal region is regarded as oil-promising on the basis of considerable exploration, but Lakhra is still wildcat territory. Diesel electric engines have been used on the rigs in Lakhra but all the Chakwal wells, including the recent No. 3 test, were drilled with steam rigs. The first Chakwal test was a 12-inch hole, the second was of smaller diameter but unexpectedly high pressure caused casing collapse and a 4-month fishing job followed.

Pakistan has created a well-staffed Geological Survey in its projected search for oil and extensive tests are planned in many areas of both East and West Pakistan. The government reports that among the first formations to be tested will be the Lower Tertiary domes of Kohistan (Sind), the Marri and Bugti country, Khaur Dhulia and Joya Mair.

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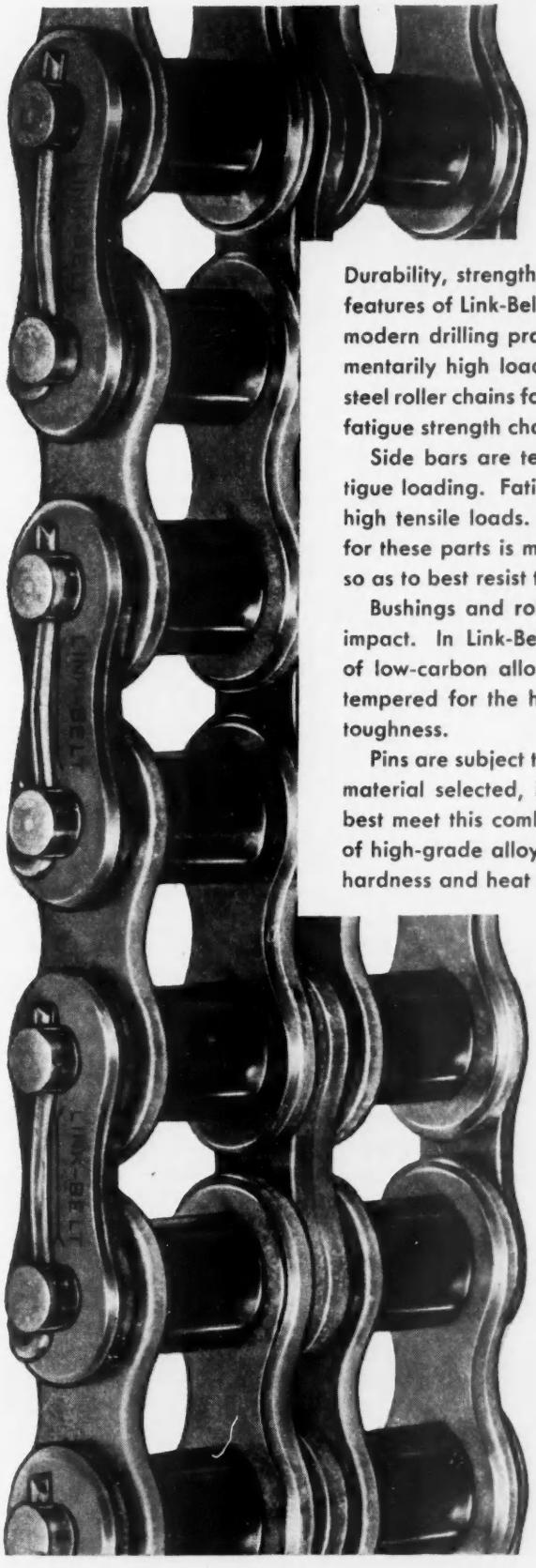

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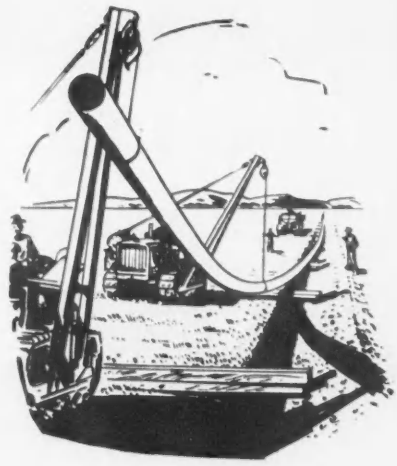

By ANTHONY GIBBON
Mid-Continent District Editor

THE benefits of recent oil discoveries in Western Canada are being extended to wider areas of that country by the construction of Canada's first great oil pipe line, which will supply Ontario refineries and overcome part of the distance problems that have handicapped further growth of the western fields. The pipe line is a major construction project involving the investment of about $90 million, including funds for contingencies and working capital. It is being built and will be operated by the newly-formed Interprovincial Pipe Line Company. Although Interprovincial was sponsored by Imperial Oil, Ltd., Imperial's primary concern was in getting oil to market, not getting into the pipe line business. Accordingly Imperial has not retained a majority interest in the new company.

The line will represent a substantial addition to Canada's transportation facilities and may be followed by similar projects of importance. This was indicated in a statement by Dr. O. B. Hopkins, Interprovincial's president, when he said: "Canada is witnessing only the beginning of a new era in oil development and in the transportation problems which may accompany it. Other pipe lines will probably have to be built to provide markets for the ever-increasing flow of Alberta's wells."

Construction of the pipe line is by far the largest project of this nature ever undertaken in Canada. The Alberta-Saskatchewan-Manitoba section will permit a more efficient distribution of the oil in the prairie provinces while the extension to Superior will provide an artery linked with the Great Lakes tanker transportation system to carry Alberta oil to Ontario refineries.

MUCH OF the oil production available in Western Canada has been curtailed for lack of outlets to eastern refineries and markets. A big-inch pipe line now under construction from Edmonton, Alberta, to Lake Superior will permit greater distribution of oil to needy prairie provinces and to refineries in Ontario, and will be a big step forward in making Canada self-sufficient oilwise.

The project involves laying about 1150 miles of pipe, and constructing pumping stations and a complete communications system.

Oil is expected to flow through the first leg of the line—the 450-mile link between Alberta and Regina—by the fall of 1950, and the Regina-Superior link by the spring of 1951.

A total of 175,000 tons of steel pipe will be required for the entire line. Canadian mills are making the 16-inch diameter pipe needed but the 18- and 20-inch diameter is being fabricated in the U. S. with all the 18-inch line being laid in the U. S. link. The pipe line route was surveyed from the air and the ground survey is completed.

Work has been started at the pumping stations at Edmonton and near Ermine, Saskatchewan. The Edmonton - Regina line will begin operation with 2 stations and the section from Regina to Superior lakehead will have 4—at Regina, Cromer, Gretna and Clearbrook, Minn.

Initial capacity of the Edmonton-Regina line will be 95,000 barrels a day, and east of Regina it will be 70,000. Refineries at Rosetown, Regina, Brandon and Winnipeg may receive about 33,600 barrels a day and the balance will go on to Superior. This drop-off will increase as existing refineries increase capacity or new refineries are built.

The capacity of the line can also be increased by addition of new pump stations and it is estimated that more than 130,000 barrels a day could be handled at Edmonton when conditions warrant an input of that quantity.

Since Superior is closed to navigation about 5 months in the year, storage capacity of at least 1.5 million barrels will be built there to permit the steady accumulation of oil during the closed season. A loading dock for lake tankers is being put into condition at Superior.

Construction of 2 new tankers, largest ever built in Canada, is part of the program. The new ships will each have a capacity of 115,000 barrels and a speed of 13 knots, which means that each can carry more than 5 million barrels of oil a year. The tankers will cost an estimated $7.8 million and will be constructed at Collingwood and Port Arthur by Canadian Shipbuilding and Engineering, Ltd. Each will be 620 feet long, 68 feet beam, and 35 feet deep with a draft of 24 feet. Deadweight tonnage will be 15,800 and engines will develop 4500 horsepower. The vessels will be ready for service when navigation opens in 1951.

At Superior the tankers will load Alberta crude at an estimated average rate of 57,000 barrels a day. This does not mean, however, that the pipe line will deliver that amount of crude every day in the year since navigation is closed for about 5 months out of the 12. In winter, therefore, the line will carry about 10,000 barrels daily into tankage at Superior and will operate at near capacity for the rest of the year.

Most of the oil will go to Imperial's big Sarnia plant but refineries at Petrolia and Toronto are also expected to receive Alberta crude.

Actual pipe laying operations started last spring with between 1000 and 1500 men employed on as many as 10 spreads simultaneously. Imperial has placed orders for all pipe at a cost of about $20 million delivered at the site.

Following a complete study of communications systems on major pipe lines in the U. S., consideration is being given to installation of a frequency modulation

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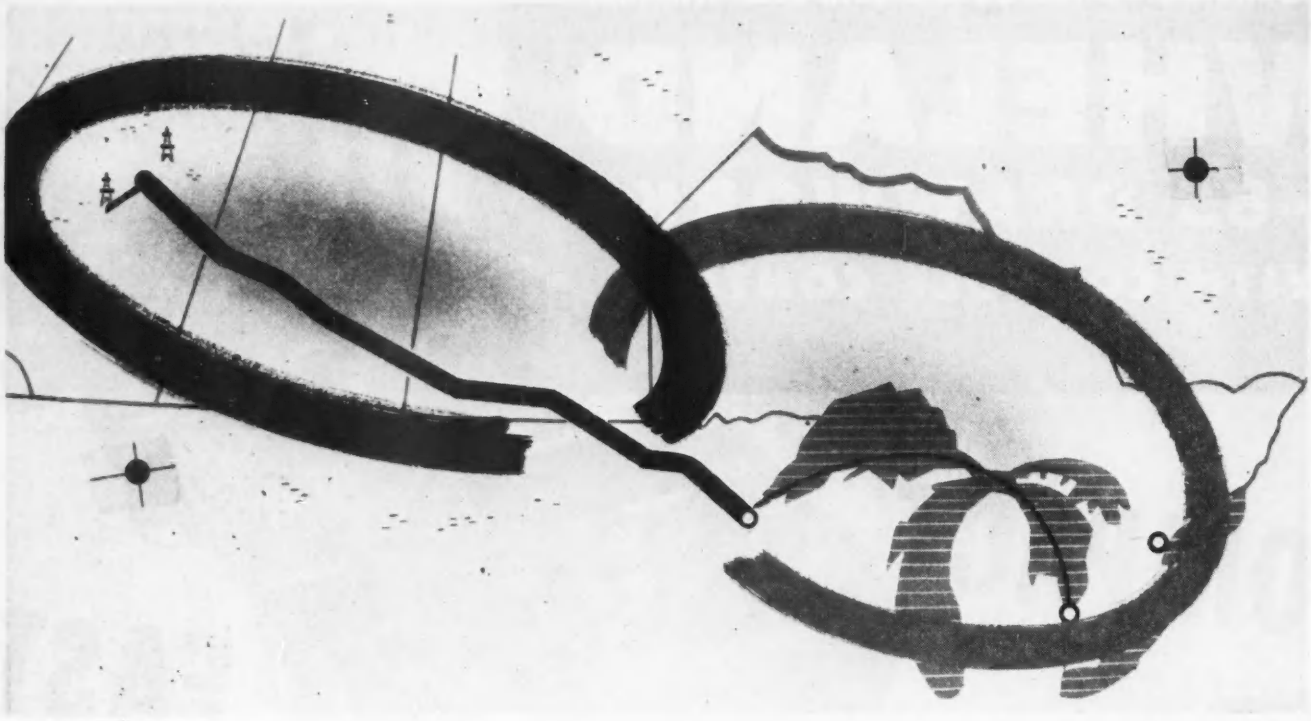

Courtesy Standard Oil Company (N. J.)

At present transportation costs limit Alberta crude to prairie area indicated by the first circle (left); Interprovincial's pipe line will break the bonds created by distance and make Canada's western oil available to its Eastern markets.

radio system and engineers are studying special equipment designed to adequately cover the distance between pumping stations, and since these are so far apart the installation will include a series of repeater stations. A teletype system is also being considered.

The line will be checked by air patrol and landing strips will be laid out at stations which are not near existing airports.

Estimated cost of constructing the line is $85 million and an additional $5 million will be available for contingencies and working capital. Interprovincial financed the project by issuing $72 million of 3½ percent, 20-year bonds, $17 million of 21-year, 4 percent convertible sinking fund debentures and 20,014 of its 4 million authorized shares of $50 par value capital stock. The bonds were offered privately to insurance companies and other financial institutions in Canada and the U. S. Of the total, $37 million are payable in Canadian and $35 million in U. S. currency. Interprovincial offered $7.5 million of the convertible debentures publicly through underwriters in Canada; the remainder was sold privately with Imperial Oil taking a substantial portion. Interprovincial has reserved 340,000 shares for conversion of the debentures at the rate of 20 shares for each $1000 of debentures. Of the 20,014 shares of capital stock outstanding, Imperial now owns 10,000, while 14 are directors' qualifying shares and the rest has been sold privately by Interprovincial to individuals.

In the U. S. a wholly-owned subsidiary of Interprovincial, the Lakehead Pipe Line Company, Inc., will own and operate all facilities and will issue to Interprovincial first mortgage bonds to meet the entire cost of these facilities.

As a result of the wide interest in the plans for the pipe line many questions have been asked about the broad aspects of the project. The following are some of the more frequent questions with brief answers supplied by the pipe line officials:

Why is the pipe line being built?

Answer: Oil production in Alberta has risen to the point where it has exceeded the requirements of the present market in the prairies and is pressing for further outlets. If the oil is to serve wider areas the great transportation handicap must be overcome. Construction of the line will provide the most economical form of transportation for oil from Western Canada, permitting it to enter Ontario markets.

Why must transportation costs for Alberta oil be kept to a minimum?

Answer: In entering areas east of Winnipeg, the present fringe of the market, Alberta crude must displace U. S. and South American crudes that are now being used in Ontario. Canadian crude has no special quality that makes it more suitable for use in Canada than many other crudes and it must, therefore, meet the price at which imported crude oil can be purchased. This price is determined by world competition plus the costs of transportation. By keeping transportation costs to a minimum the pipe line will enable western oil to compete with foreign oil in Ontario markets.

Why wasn't an all-Canadian route chosen for the pipe line?

Answer: Because the shortest and least expensive line that can be built to the Great Lakes is to the general advantage of the oil producing provinces and of Canada as a whole. To build the line to Fort Williams or Port Arthur instead of running it from the Manitoba border to Superior, Wis., would have involved greatly increased construction costs, much higher operating and maintenance costs, and considerably more time.

Why would it cost more to go to the Fort William-Port Arthur area than to Superior, Wis.?

Answer: In the first place, because the line would have to be 121 miles longer, entailing not only the laying of additional pipe but construction of additional pumping stations. Moreover, the extra 121 miles would be part of a section of almost 300 miles, from the Manitoba-Ontario boundary to the lakehead cities, that would be the most difficult and costly construction project of the entire line. The rest of the Canadian section of the line will pass through the prairies where construction will be comparitively uncomplicated, but from shortly east of Winnipeg, the Canadian area is wild country, largely lakes and rocks, rivers and other obstacles. These conditions would greatly add to construction costs and the engineering problems involved

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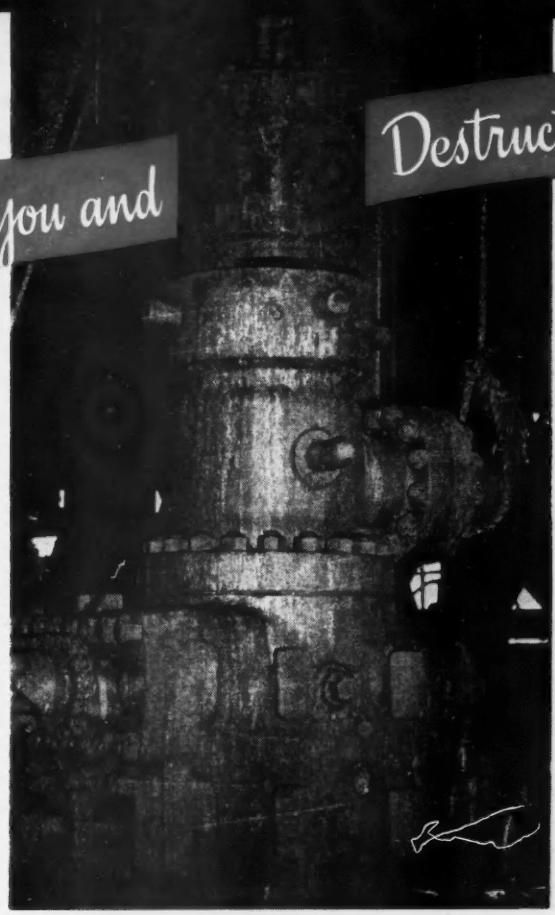

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A heavy-duty Hycar oil and gas resistant rubber stripper, which is designed to pack-off on the Kelly, tool joints, drill pipe, subs and drill collars, rotates with the pipe and provides a constant seal of the well bore while the pipe is in the hole. This rugged rubber stripper withstands the extreme stresses caused by raising and lowering the Kelly and drill joints through it.

Here is another instance in which Murray's specialized experience in compounding and molding "the right rubber for the job" has contributed directly for the success of a new tool for the oil industry. Extremely close laboratory control and careful molding and finishing of this stripper assures uniform high quality and dependable performance. Certainly, there is no substitute for such experience, coupled with the largest, most modern mold manufacturing and rubber producing plant in the South.

This is the big, rugged, Hycar rubber stripper which is molded by Murray for the new Shaffer Rotating Blowout Preventer and Stripper.

MURRAY RUBBER COMPANY

HOUSTON, TEXAS

Courtesy Standard Oil Company (N. J.)

Canadian line being machine wrapped with fiberglass and tar paper to minimize corrosion.

would seriously delay the completion of the line. By going to Superior the line will avoid these costs and problems because the land continues comparatively flat along that route.

Would not an all-Canadian pipe line develop new traffic in the area crossed and so make the extra cost worthwhile?

Answer: No. The longer and less efficient route would not result in compensating benefits. A pipe line, unlike a highway or railroad, has almost no effect upon the area through which it passes. A highway or railway can serve settlers and industries along its route and help the growth of new communities. A pipe line is built to carry a single raw material, oil, to points where it can be used, and it carries its freight in one direction only. It affects the area through which it passes only if refineries can be located in the area, and refineries are built only where they can serve markets more advantageously than existing sources of supply.

Is it possible that the line may be used to export Alberta oil to the United States?

Answer: This is a possibility which will depend on future developments: whether the U. S. wants Canadian oil, Canada's national policy, growth of reserves, expansion of the pipe line's carrying capacity, changes in crude prices and other economic factors. The requirements of the prairie provinces are being met first and the line is being built to help supply Ontario. At the planned initial rates of operation of the line there appears to be an adequate market in Ontario for all the crude delivered at Superior.

If some Alberta oil were exported would this reduce the crude supplies available for Canada?

Answer: No. On the contrary, it would make Canada's supplies more secure because it would ease the strain on scarce U. S. dollars. Also, because of transport costs, prices for crude are higher in the inland areas of North America than along the Atlantic Seaboard. By exporting Alberta crude to the inland U. S. markets, Canada would obtain money which would buy large quantities of oil for the eastern provinces where imports are necessary. By exporting at some points and importing at others Canadians not only save heavy transport costs within the country but make supplies more assured for the parts which must continue to import oil.

Western Germany Produces Shale Oil from Messel Mine

In addition to the crude oil production from the fields in the northwestern part of the country and in Baden, Western Germany has a small and generally unknown supply of oil from shale. This is from the mine at Messel, a few miles northeast of Darmstadt, between Frankfort and Heidelberg, in the American occupation zone of Germany. Up to 2 years ago, a second shale mine was in operation near Balingen in Wuerttemberg—the French zone. Here, during the war, low temperature plants were erected at an excessive cost to extract oil from the Liassic shale; however, the mine proved to be commercially unproductive and the project was abandoned. The Messel plant, however, operates at a profit, and during 1949 processed 136,800 barrels of shale oil.

The shale deposit being worked at Messel covers an area of about 200 acres and is essentially bowl-shaped, being about 600 feet thick in the middle and thinning out toward the edges. The shale itself contains from 5 to 11 percent oil and the estimated oil reserves for the deposit are about 216 million barrels—a figure of some significance to Western Germany. Brownish-black in color, the shale is laid down in laminated beds which make open-cut mining methods readily adaptable. As received at the processing plant the shale consists of about 40 percent water and 35 percent ash.

At present, daily shale output is about 960 tons, of which 750 tons are charged into the 30 ovens of the low temperature plant and the remainder is used for fuel for the power plant and the crude oil distillation unit. Daily oil output from this shale is about 347 barrels of heavy paraffin oil, 33 barrels of condensate and 30 barrels of naphtha. About 10 percent of the residue is sold to paint factories as a base for black paint. The gases from the extraction process are all collected and converted to useful by-products. The crude and light oils obtained are further distilled and refined into their component parts for commercial use.

To eliminate waste in the shale processing work, the shale residues remaining, after the hydrocarbon extraction, are converted into porous building bricks—similar to the cinder bricks being made in the U. S.

While operating on a small scale, in view of the oil demand in Germany, the Messel plant is important in that it saves rare dollars, does not require government subsidies, and supplies valuable by-products.

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Shell Oil Company Reports On 1949 Worldwide Operations

THE worldwide companies of the Royal Dutch Shell Group produced 372.8 million barrels of crude oil and natural gasoline during 1949, as against 343.7 million barrels for 1948, according to the annual statement of the Royal Dutch Petroleum Company. The production increase of 8 percent is explained as a result of "the Group's policy of endeavoring as far as possible to meet requirements of the Group's normal trade from our own sources of crude oil production and crude accruing to the Group under long-term contracts."

The report says the Shell Group companies have large reserves in the Western Hemisphere to meet expanding demand, and are also assured for many years of the continuance of large supplies from the Middle East. The following table lists Royal Dutch Shell Group production by countries, for 1948 and 1949, in millions of barrels:

Country	1949	1948
Venezuela	150.6	146.0
U. S. A.	77.0	84.6
British Borneo	25.1	20.1
Indonesia	20.7	16.0
Egypt	12.3	11.5
Colombia	7.8	6.3
Iraq	6.3	5.2
Trinidad	5.5	5.4
The Argentine	3.6	3.7
Netherlands	2.2	1.7
Austria	0.7	0.7
Germany	0.3	0.2
New Guinea	0.7	0.1
Received under long-term contract	60.0	42.2
TOTALS	372.8	343.7

In commenting on its production levels in various countries, the report notes that in Colombia, the potential production of the Casabe field was raised about a third, although output was restricted by inadequate pipe line capacity; in the Netherlands the productive area of the Schoonebeek field was extended considerably, as was production from the Seria field in British Borneo. Output was increased in Indonesia despite political disturbances, although the productive capacity of many fields has suffered severely because of development practices by the Japanese during the occupation of the islands.

The Shell Group carried on an active exploration program for all of 1949. In Eastern Canada the examination of the holdings in New Brunswick was nearly completed. "The results of this work," says the report, "have been far from encouraging and at the beginning of 1950 it was found that prospects did not warrant continuation of the operations." The concessions were surrendered. In Western Canada Shell Oil Company in equal partnership with Shell Caribbean Petroleum Company acquired rights over 4 million acres in Alberta and Saskatchewan.

In Venezuela exploration was concentrated in the western part with important extensions to the heavy oil reserves in the Bolivar district. Particular attention was given to the possibility of increasing the light oil reserves in the limestone formation from which production is obtained in the La Paz and Mara fields.

Disappointing results in Ecuador caused Shell early this year to discontinue exploration work and surrender its concession on which about $30 million had been spent in joint venture with American capital.

In the Netherlands gas was discovered in an exploration well at De Wijk, province of Drente. In consequence application for an extension of the Schoonebeek concession from 37,000 acres to 230,000 acres was filed. In the Middle East drilling by the Iraq Petroleum Company, in which Shell holds 23.75 percent interest, resulted in significant discoveries at Zubair and Nahr Umr around Basra, at the head of the Persian Gulf. In British Borneo the proven reserves of the Seria field in Brunei were substantially increased by successful step-out drilling.

Shell made good worldwide progress in extension of its refining capacity, processing a total of 395 million barrels during 1949 as compared to 353 million barrels the preceding year.

The annual report of the Shell Group shows a growth of 300,000 deadweight tons in the total tanker tonnage controlled and chartered by the Group and associated companies. The total now exceeds 4 million deadweight tons. Four 28,000-ton tankers are being built in the United Kingdom, the first of which is scheduled to be in service by August, 1951, according to the company's report.

Superior's Qatar Concession Boundaries Are Clarified

An offshore drilling concession in the sheikdom of Qatar, held jointly by Superior Oil Company and the Central Mining and Investment Corporation, a London firm, was clarified last month. The concession covered a 12-mile belt offshore around the Qatar peninsula and encompassed about 6 million acres of seabed; however, Petroleum Development Company (Qatar), Ltd., previously had acquired a 75-year lease on the entire peninsula, and there was some question as to whether this latter lease included some of the offshore territory. Agreement has been reached with the companies involved and the sheikdom whereby Petroleum Development's concession includes that portion of the seabeds 3 miles from the shore, around the peninsula, and Superior's holdings begin at the 3-mile point.

Second Neutral Zone Well Dry

American Independent Oil Company and Pacific Western Oil Corporation, operating jointly in the Neutral Zone, between Kuwait and Saudi Arabia, reported their second well drilled as dry. The operators' first well, drilled in 1949, was abandoned as dry at 5020 feet and the second well was a west offset intended to develop an indicated structure. The companies emphasize that neither well was drilled with the express intention of seeking production, but were more in the nature of geologic test wells.

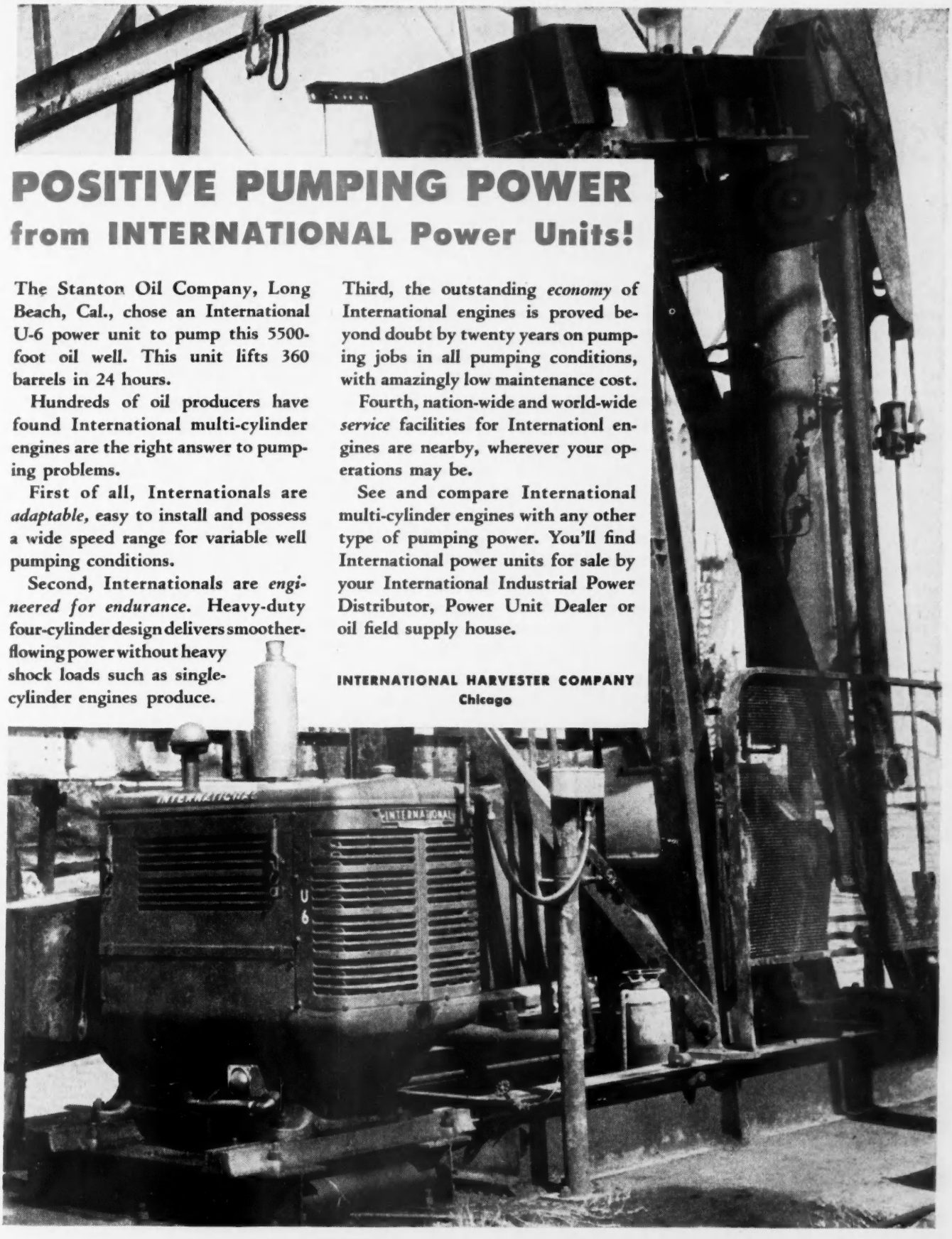
Pemex Announces Increase In Production and Drilling

Petroleos Mexicanos, the Mexican petroleum administration, announced a 26 percent increase in crude oil production for the first quarter of 1950 over the corresponding period of 1949. Production for March was 5,854,872 barrels, or 188,867 barrels daily, as compared with the yearly average for 1949 of 166,401 barrels per day.

Forty oil wells were drilled during the first quarter of 1950 as compared with 30 wells in the same period of 1949—with a footage increase of 60 percent.

Iraq Wants New Oil Pact

Iraq is presently pressing for changes in its oil agreement with Iraq Petroleum Company, the sole operating company in the country. Essentially, the Iraqi government requests that the present oil royalty of 4 shillings per ton (about 8 cents per barrel), based on gold, be increased; that the royalty payments be made in gold; that the royalty oil accruing to the government be transported free to the Mediterranean Coast; and finally, that more Iraq nationals be hired to replace foreign personnel now employed.



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INDUSTRIAL POWER

Increased Production in Chile Speeds Refinery Construction

PROJECTED increases in Chile's crude oil production from the Cerro Manantiales (Spring Hill) field have spurred plans for the construction of a refinery to supply a major part of Chile's domestic oil requirements at the same time that the country steps up its crude oil export program. Chile is relying heavily on this two-way measure of raising the level of its national economy —virtually making itself free of the need for product importation while it expands its shipments of crude oil to several neighboring South American republics.

Spring Hill Well 30 came in March 9, and 31 on March 13, both at 7500 feet. Well 32 is now drilling on the northeast flank of the Spring Hill structure. Four rotary rigs are now on the ground at Spring Hill and its northerly outstep of Espora and the San Sebastian structure, 55 miles to the south. The Corporacion de Fomento de la Produccion, Chile's state oil monopoly, is to be given a more autonomous legal status to allow it greater flexibility in developing the Spring Hill region, the world's most southerly oil field, located on the north tip of Tierra del Fuego, at the Straits of Magellan. CORFO is now studying closely plans for a stepped-up drilling program to raise the field's production from the current 2000 barrel a day potential level to 10,000 barrels daily by 1955.

Construction of the Chilean refinery has been discussed for several years. CORFO initiated specific studies for the plant in 1945, even before the discovery of oil at Spring Hill. At that time an American technician was engaged to make a preliminary report on the feasibility of a refining plant and a desirable site for its location. But in December, 1945, while this study was still under way, oil was found at Spring Hill and all plans for the plant were suspended until the character of the new oil and the possible value of the field could be determined.

By the time Spring Hill production was approaching 1500 barrels a day, it was fairly definitely determined to locate the proposed refinery on the straits to handle crude from this field—perhaps supplementing the domestic output with imports. Meanwhile the field's output has been exported on an increasingly wider and more regular basis. Chile's second shipment of crude to Uruguay is scheduled to be loaded early in July at the terminal Caleta Clarencia on Gente Grande Bay, 43 miles from the Spring Hill field and connected with the field by an 8-inch pipe line.

The new refinery will yield not only the basic products of gasoline, kerosine, diesel oil and fuel oil, but specialty products and lube. At present Chile's imports of diesel and fuel oil, for use in connection with her nitrate and copper industries, are of such magnitude as to be wholly disproportionate to gasoline imports. CORFO has been seeking to solve the problem of relative yields on an economic basis so that Chile's gasoline requirements can be filled by the same plant that cares for the diesel oil and fuel oil needs.

It is expected that a plant of about 12,000 barrels a day throughput will be recommended, with limited cracking facilities, at a cost of about $12 million. Construction of the lube plant will be delayed to reduce initial cost. Table 1 presents unfinalized programming of the plant in terms of dollar value output and barrelage.

TABLE 1

	b/d	U.S. Dollars Per 1 Lb.	U.S. Dollars Annually
Gasoline	6,100	4.65	10,300,000
Kerosine	1,080	3.96	1,560,000
Diesel Oil	2,060	3.82	2,860,000
Fuel Oil	1,610	2.61	1,540,000
Lubricants	360	28	3,640,000
Paraffins	140	32	1,600,000
Gas	130,000 cu.m.	2.20	
			21,500,000

Value of the crude which the plant will acquire and the cost of processing are estimated as shown in Table 2.

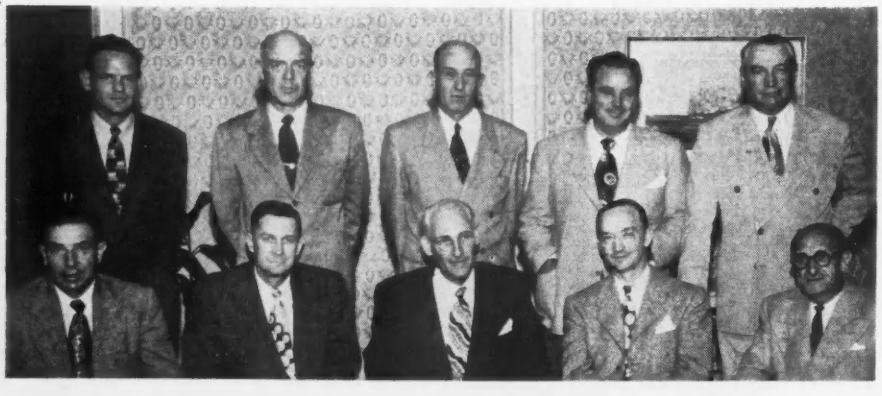
TABLE 2

			(Annual)
Crude Oil	12,000 b/d	$3.25	$14,300,000
Process Cost		.75	3,300,000
			17,600,000

The Chilean Senate recently received a report by Senator Carlos Alberto Martinez showing that CORFO's investment in the nation's petroleum program had reached the total of 568,124,826 pesos, distributed as follows:

Geological and geophysical work	90,000,000
Well drilling and production facilities	200,000,000
Machinery supplies	150,000,000
Pipe line	75,000,000
Port works, roads, etc.	35,000,000
Miscellaneous	18,000,000

Contracts with foreign companies for technical studies, including United Geophysical, for drilling (Livermore), and control of wells (Compania de Investigaciones Geofisicas Schulemberger, have cost 80,309,500 pesos, according to the report.



Foreign Guests at a recent meeting of the Los Angeles Chapter of Nomads are, left to right, first row, R. E. Lorenz, Iraq Petroleum Company; John E. Sligh, IPC; E. N. Mitchell, Philippine Oil Development Company; Eugene L. Davis, Arctic Contractors; C. E. Bickerdike, Wm. Kenyon & Sons, Ltd. Second row, Walt L. Sears, IPC; Karl L. VonderAhe, Arctic Contractors; L. E. Miles, IPC; David L. Cantway, Mene Grande Oil Company; and J. D. Bryan, Superior Pipe Service.

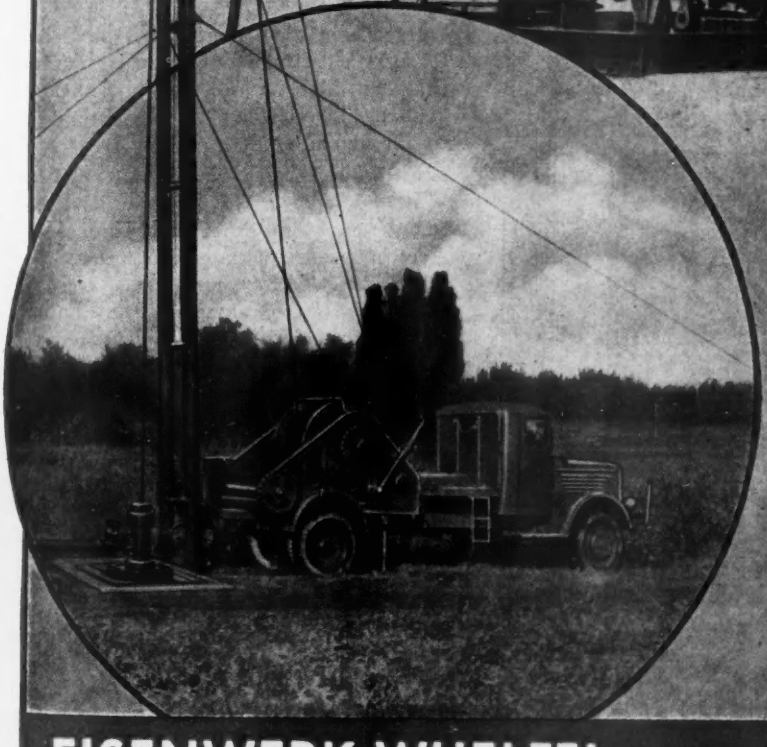
Saudi Arabia Production Gains Are Up 15 Percent Over 1949

Crude oil production in Saudi Arabia in May amounted to 17,078,238 barrels, or an average of 550,911 barrels per calendar day. This production compares with the yearly average for 1949 of 447,300 barrels daily, an increase of more than 15 percent.

Wülfel

OILFIELD-EQUIPMENT

MADE IN GERMANY



embodies more than 20 years experience gained in foreign fields.

Please write for bulletins referring to

- PUMPING UNITS
- CENTRAL POWERS
- SINGLE OR DOUBLE DRUM WINCHES
- TELESCOPING MASTS

EISENWERK WUELFEL · HANNOVER-WUELFEL · GERMANY

Gulf Subsidiary Will Operate Small Tanker Fleet in Brazil

A FLEET of 3 small barges especially designed for short distance transportation of gasoline are ready to be placed in service by Gulf Oil Corporation's Brazilian subsidiary, Brazil-Gulf, (Cia Brasileira de Petroleo Gulf) to supply the Rio de Janeiro area.

The all-welded steel barges, constructed and launched at the Pittsburgh shipyard of Dravo Corporation, were towed to New Orleans and loaded on the deck of a Delta Line ship for the ocean trip to Rio de Janeiro.

Only 77½ feet long, the little vessels can carry approximately 1250 barrels of gasoline with a draft of about 6 feet.

They will operate in Guanabara Bay between Brazil-Gulf's bulk storage terminal on Pancaraiba Island and the company's new distribution terminal just outside the city limits of Rio.

The 8-mile shuttle trip from island to mainland is necessitated by Brazilian government limitations on the amount of gasoline which can be stored on the mainland. Gulf's new distribution terminal is located on property assigned by the government for this purpose in the Caju district of Rio. Previously, shuttle barges from the island bulk storage depot had to discharge directly into tank cars or tank trucks at Rio's city docks.

The storage capacity at the distribution terminal is approximately 29,000 barrels and facilities are arranged for loading tank trucks and tank cars. There are 6 storage tanks at the terminal.

Barges will be moored at a concrete pier with 325 feet of water frontage. Depth of the water is only 8 feet, however, which limits the draft of the vessels using the pier. The new barges were designed to carry as much gasoline as possible with a draft of 6 feet or less. They are suitable for towing on a hawser behind a tug in the choppy waters of the bay.

Over-all dimensions of the Dravo-built barges are 77½ feet molded length, 22 feet molded width, and 8 feet molded depth. Both ends of the barge are toed in to a width of 12 feet. The stern has a pair of anti-yaw skegs to keep the barge from side-slipping while being towed on a line.

Cargo will be carried in 2 compartments between the fore and aft collision bulkheads of the vessel. The capacity of one compartment is 3 times that of the other and they are separated by a transverse oil-tight bulkhead. The larger compartment has 2 transverse swash bulkheads to retard movement of the liquid cargo when the compartment is partially filled.

Expansion trunks are fitted on deck toward the aft end of each cargo compartment. These are 3 feet in diameter, 2½ feet high and have an oil-tight hatch on the manhole.

Each barge has 2 cargo pumps driven by 20-horsepower, 1760 revolutions per minute explosion-proof and waterproof electric motors, operating on 3 phase, 60 cycle, 220-440 volt current. A reel of cable is provided alongside the motors for connecting with shore current supply.

Either deep well pump can discharge cargo from either tank through 4-inch suction lines. Two different types of cargo can be carried and discharged without contamination, and one pump can serve both tanks if the other pump is inoperative. Either pump can deliver 350 gallons of gasoline per minute against a head of 160 feet. This enables them to discharge cargo directly into any of the 6 storage tanks at the terminal without a booster pump.

Pumps are on the stern of the barge and shielded with an awning. A small davit is installed to handle the hose lines on the stern and another davit on the bow handles the 750-pound anchor.

ARE YOUR WELLS SUFFERING FROM
PARAFFINITIS*?
Wells afflicted with this disease can be cured by the installation of Huber Paraffin Scrapers. They are not just a temporary relief, but a Permanent Cure. Your wells will never again need costly steaming out or the rods pulled to keep them on production.
Huber scrapers, shrink-fitted to the rods and placed in the area of accumulation, wipe the tubing walls clean of paraffin as the rods are rotated and reciprocated. It is as simple and efficient as that.
ROTATION . . . a double benefit
Huber scrapers combined with a Huber Rotating Rod Hanger give double benefit in paraffin removal. The resulting rotating and reciprocation motion wipes paraffin from the tubing in particles so small that they go out in solution . . . can not clog tubing, scrapers, or flow lines. Double benefit rod rotation prolongs coupling life by equally distributing wear . . . prolongs pump life and efficiency by equalizing wear on working barrel.
* Congestion caused by the accumulation of paraffin in pumping wells.
For further information see your local supply store, or write
J. M. HUBER CORPORATION,
Box 831 . . . . . Borger, Texas
HUBER
PARAFFIN SCRAPERS
SCRAPE AS THEY ROTATE AS THEY RECIPROCATE

Get longer service in corrosive wells with . . .

Sucker Rods of "K" Monel

Replacing strings because of sucker rod failure is expensive.

But it's no longer a necessary evil. "K"* Monel sucker rods have seen to that! They last for years in wells where other rods fail in weeks.

Serving in some of the most corrosive areas of West Texas, for example, "K" Monel rods have bucked a wide range of sour crudes and brines – and won out *every time.* (Three typical case histories are briefly reviewed in the panel at the right.)

"K" Monel, in addition to providing such high resistance to corrosive media, also resists abrasion and wear. It withstands stress, vibration and flow-cutting.

High Fatigue Strength

And "K" Monel has other important features, too. It can be used under the conditions existing in oil and gas wells without significantly accelerating corrosion of the steel equipment with which it comes in contact. Nor is its fatigue strength significantly affected by the presence of oil well corrosives.

Heat-treatable and non-magnetic, "K" Monel's tensile strength can be developed to 140-170,000 psi, and its hardness to 25-35 Rockwell "C." Thus you get strength and hardness comparable to heat-treated alloy steels—and you have all the corrosion-resisting, wear-resisting properties of "K" Monel besides!

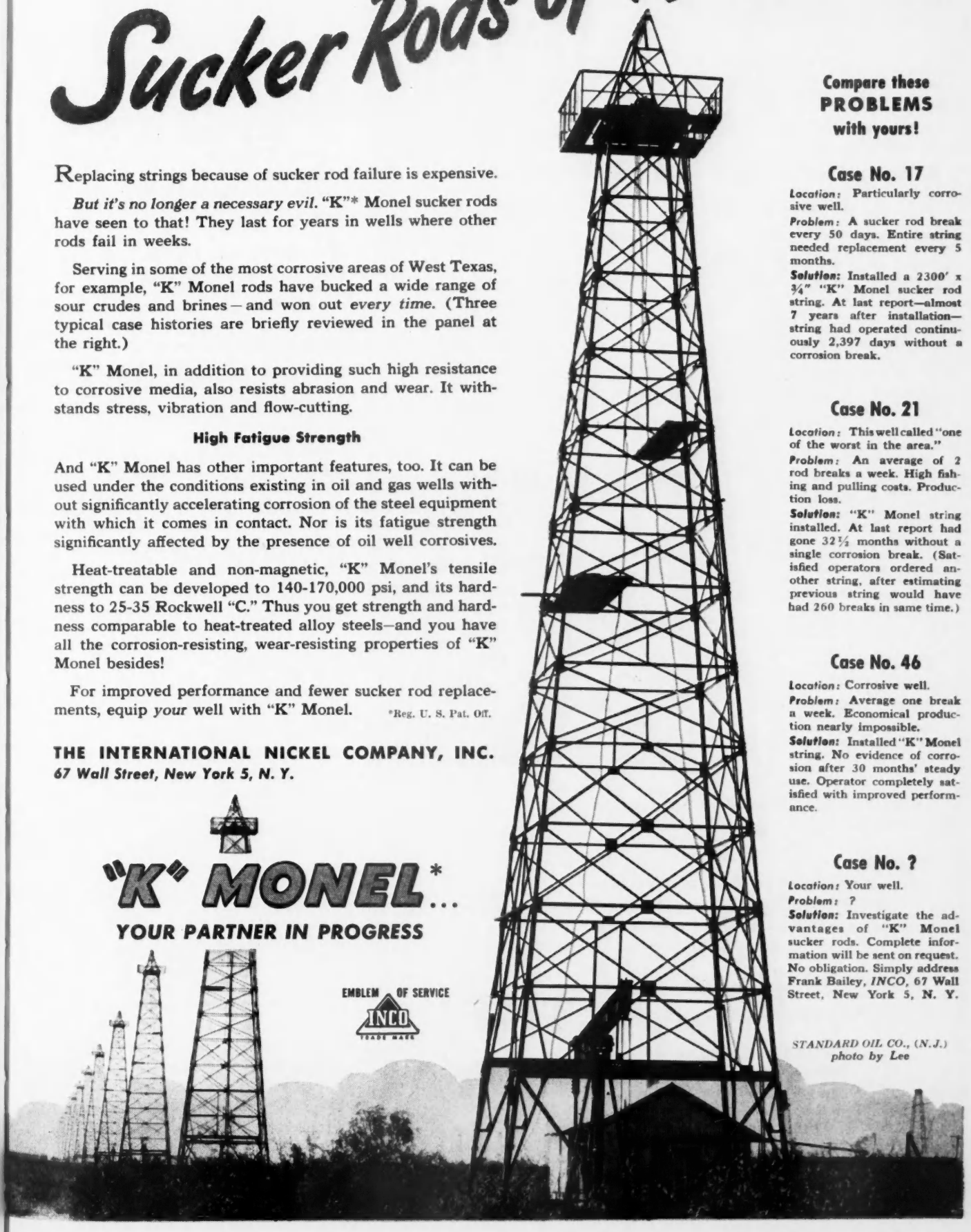
For improved performance and fewer sucker rod replacements, equip *your* well with "K" Monel. *Reg. U. S. Pat. Off.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

"K" MONEL*...

YOUR PARTNER IN PROGRESS

EMBLEM OF SERVICE
INCO
TRADE MARK



Compare these PROBLEMS with yours!

Case No. 17

Location: Particularly corrosive well.

Problem: A sucker rod break every 50 days. Entire string needed replacement every 5 months.

Solution: Installed a 2300' x ¾" "K" Monel sucker rod string. At last report—almost 7 years after installation—string had operated continuously 2,397 days without a corrosion break.

Case No. 21

Location: This well called "one of the worst in the area."

Problem: An average of 2 rod breaks a week. High fishing and pulling costs. Production loss.

Solution: "K" Monel string installed. At last report had gone 32½ months without a single corrosion break. (Satisfied operators ordered another string, after estimating previous string would have had 260 breaks in same time.)

Case No. 46

Location: Corrosive well.

Problem: Average one break a week. Economical production nearly impossible.

Solution: Installed "K" Monel string. No evidence of corrosion after 30 months' steady use. Operator completely satisfied with improved performance.

Case No. ?

Location: Your well.

Problem: ?

Solution: Investigate the advantages of "K" Monel sucker rods. Complete information will be sent on request. No obligation. Simply address Frank Bailey, *INCO*, 67 Wall Street, New York 5, N. Y.

STANDARD OIL CO., (N.J.) photo by Lee

Negotiations Are Under Way To Build Refinery at Haifa

Israeli government officials are negotiating with American oil interests for the construction of a new oil refinery in Haifa, Palestine, and the granting of exploratory petroleum rights in Israel. The conversations came to light when Bartley C. Crum, former member of the Anglo-American Committee on Palestine, who visited Israel in behalf of American independent oil operators, announced in Tel Aviv that he had received the "green light" to invite his principals to Israel to discuss terms of the concession and contract. Crum later corrected this statement, saying Israel had not yet decided to grant such rights, but was merely considering such a deal.

Edwin Pauley, well known American independent oil man associated with American Independent Oil Company and other interests, was mentioned as one of the principals with whom the Israel government would negotiate. Also, Max Ball, geological consultant of Washington, is reported to have been approached by Israeli interests for his services in an active hunt for oil in Palestine.

The Haifa refinery of the Consolidated Refineries, Ltd., a plant with present capacity of about 85,000 barrels a day, has been closed for nearly 2 years because of the Israeli-Arab dispute and the refusal of the Arab state of Iraq to permit crude oil movement through the Iraq Petroleum Company's pipe line from the Kirkuk field to Haifa.

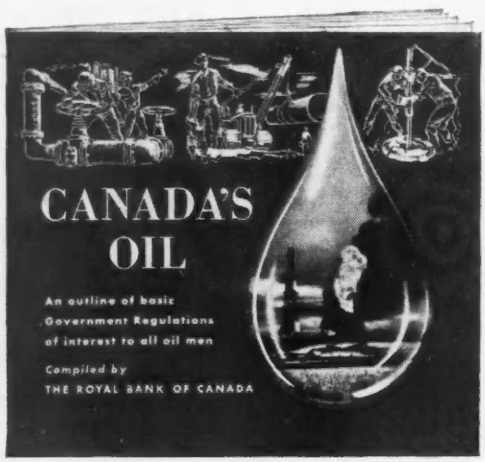
For more than a year Israel has been trying to open the plant on crude imported by tanker from the Caribbean and other sources. Recently Tel Aviv officials announced they had reached an agreement with Consolidated officials in London by which the Haifa plant would reopen on Anglo-Iranian crude, presumably tanker-hauled from the Persian Gulf to Palestine.

Canada's Oil...

A new brochure has been prepared by The Royal Bank of Canada, "Canada's Oil Bank," to provide basic information for oil men interested in Canada's oil fields. It is factual, comprehensive and up-to-the-minute.

Here are the important subjects covered in this new brochure—

- Leases and Reservations
- Conservation and Proration
- Immigration
- Minimum wages and holidays with pay
- Business operations in Canada
- Taxation
- Tariffs and Customs Regulations
- Foreign Exchange Control
- Western Canada Petroleum Association



Maps of Western Canadian oil fields, showing locations of The Royal Bank branches are also contained in the book.

Copies are available on request to the Advertising Department, Head Office, Montreal. Please write on your business letterhead.

Ask the Royal about Canada's Oil

57 branches in Alberta, the "oil" province. Over 730 branches in Canada, the West Indies, Central and South America, New York, London and Paris.

Head Office, Montreal
Assets exceed $2,334,000,000

THE ROYAL BANK OF CANADA

Two Balkan Countries Attempt To Increase Oil Production

Both Albania and Yugoslavia are attempting to bolster their domestic supplies of crude oil. Output from Albania is reported to be 990,000 barrels for the first half of 1950 with 70 percent of the production coming from the Devoli field and the remainder from the Berat and Skodra Lake fields. The Russion mission at Tirana has taken over control of the production from these fields as well as the refinery operations at Batum. Development of the Berat and Skodra Lake fields has been slow because Albania depends on Russia for drilling equipment. The small satellite requested drilling rigs capable of drilling to the 6560-foot production in the two fields as well as 10,000-foot capacity rigs to develop northern areas of the country; however, Russia indicated that it would supply only 3 small rigs which could not drill below 5000 feet. These would almost be useless in Albania's present operations.

Albanian geologists claim to have found oil along the Greek border, northeast of Santi Quaranta Beach, which would produce 1,980,000 barrels a year for 20 years if properly exploited. The Russian mission has indicated that this area will not be developed at this time as the area is considered to be a military district, vulnerable to enemy nations in time of crisis.

Yugoslavia reports a crude oil output of 646,800 barrels for the first half of 1950. The country is hard pressed to develop its domestic supply of crude because of the severance of diplomatic and economic relations with Moscow. The government reportedly has allocated $60 million for the purchase of drilling and research equipment to carry on work along the Albanian border, in central Bosnia and in Ulcinj, Dalmatia. The latter area is said to have an oil structure capable of producing 2,640,000 barrels a year for the next 10 years when it is fully developed.

Venezuelan Crude Production Rate Continues to Increase

With increased world consumption, Venezuela's production of crude oil continues to increase. For the week ending June 26, daily oil production totaled 1,586,866 barrels, broken down by companies and sections of the country as shown in Table 1.

Dr. Manual R. Egana, the Minister of Fuels, in Venezuela, has announced in Caracas that the ending of the U. S.-Mexico trade pact in December will return U. S. imports of foreign oil to the restrictions of the quota system established by the reciprocal trade agreement of 1939. Imports will be limited to 5 percent of the quantity of crude refined in the U. S. at the present tariff of 10½ cents per barrel, and any amount over this will be taxed 21 cents per barrel.

Both Minister Egana and U. S. Ambassador Walter J. Donnelly have expressed the opinion that this change will have no serious effect on the Venezuelan economy or on U. S.-Venezuela trade because of the rise in U. S. production and refinery runs.

Drilling activities in the spotlight near the end of June included completion of Shell Oil Company's P-108 well, north of the La Paz field, for 6500 barrels per day. The same company abandoned its VL-2 well, an Eocene test 12 miles out in Lake Maracaibo, at 7125 feet. Richmond Oil Refining Company abandoned its Cretaceous test, Zulia 34D-1, 39 miles southwest of Maracaibo, at 13,400 feet. Another Cretaceous test by the same company, 9 miles south of Maracaibo, was plugged back from total depth of 13,602 feet to test shallower sands.

Atlantic Refining Company was trying for deep production in their Ruiz 3-33, scheduled to go to 9000 feet in the Ruiz field where production is normally found between 4000 and 5000 feet. Sinclair was rigging up on their Guere 1 the first of July, about 4 miles west of Mene Grande's Los Mangos 1, a new field discovery in Anzoategui.

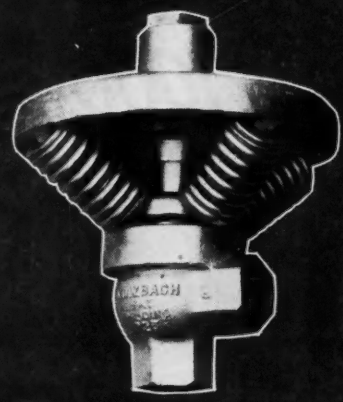
TABLE 1

COMPANY	Western Venezuela	Eastern Venezuela	Daily Total
British Controlled Oil Fields	991	.....	991
Creole Petroleum Co.	546,296	137,197	683,493
Mene Grande Oil Co.	66,138	205,831	271,969
Pantepec Petroleum Co.	.....	13,040	13,040
Phillips Petroleum Co.	.....	8,376	8,376
Richmond Exploration Co.	18,688	.....	18,688
Shell Oil Company	468,153	.....	468,153
Sinclair Oil Company	.....	13,015	13,015
Socony-Vacuum Co.	.....	36,729	36,729
Texas-Mercedes Petroleum Co.	22,947	27,140	50,087
Venezuelan Atlantic Refining	99	22,226	22,325
Total Daily Average	1,123,312	463,554	1,586,866

KINZBACH Announces...

THE KINZBACH *Automatic* MUD RELIEF VALVE

The *Only* Mud Valve with *Positive Snap Open—Snap Shut* Action



AT last positive automatic relief of overload pressures in mud lines is possible. The new Kinzbach Model 112 Relief Valve provides safer, more efficient pump or pressure relief and greater flexibility in operations than any other valve.

The Model 112 operates on working pressures from 750 to 2500 p.s.i. It Snaps Open for instantaneous pressure relief at maximum volume. It Snaps Shut to restore circulation instantly and automatically after a pre-determined pressure drop.

The Model 112 Valve can be used for any mud relief application, including compounding operations. Field tests prove conclusively that the Kinzbach Valve offers every operational advantage required for efficient mud operations. Write for full technical data. Ask for bullentin 11250.

KINZBACH TOOL CO., INC.

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Export Office:
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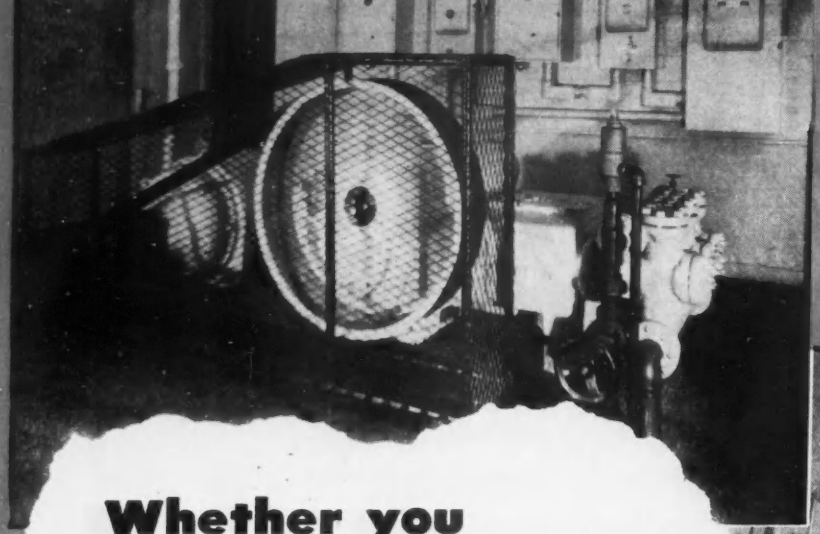
KINZBACH TOOL CO INC



Single flooding unit installation of an "Oilwell" No. 46-P Triplex Plunger Power Pump—may require additional units as flood expands.

A typical multi-stage installation of 18 "Oilwell" No. 46-P Triplex Plunger Pumps in one battery near Bradford, Pa.

Whether you have to waterflood *10 acres or 1000*

...use "Oilwell's" High-Pressure Triplex Plunger Pumps specifically designed for waterflooding

SINCE 1944, when "Oilwell's" heavy-duty, horizontal single-acting, triplex plunger pumps were first installed for waterflooding, operators everywhere have acclaimed them as unsurpassed for this service.

"Oilwell" Triplex Pumps assure a selection of volume and pressure to meet the needs of both small and large producers in applications where the pumps are never shut down once they are put into operation.

Check these advantages

- Pumps may be easily added to the line whenever "expanded flood" makes this necessary. They may be similarly removed as flood reaches final stages.
- Standby protection requires only a fraction of total investment where multiple units are used.
- Interchangeable fluid ends enable operators to start operations at medium pressures and increase as necessary to higher pressure operations. Special assemblies can be supplied to meet severe corrosive conditions.
- Wide selections of plunger sizes are available, for each of the four pumps, to meet the most rigid conditions of pressure-maintenance applications.

Select from "Oilwell's" line of Triplex Plunger Pumps the one best suited to meet your demands.

Pump Type	Types of Plungers Available	Plunger Sizes Available, Inches	Max. H. P. Input	Recommended Operating Speed Range R.P.M.	Theoretical Displacement Range with Available Plungers at Recommended Speeds - G.P.M.	Max. Pressure with Available Plungers-P.S.I.
No. 36-P	Stainless Steel Hardened Steel Porcelain	2 2¼ 2½ 2¾ 3	75	40-140	10-34 13-43 15-54 19-65 22-77	2800 2510 2040 1680 1420
No. 46-P	Stainless Steel Hardened Steel Porcelain	3½ 4 4½	75	40-140	30-105 39-137 50-174	1040 795 630
No. 48P-HD	Hardened Steel	4	280	25-175	32-228	3800
No. 58P-HD	Hardened Steel	5	280	25-175	51-355	2440

Ask for our latest Triplex Plunger Power Pump Booklet No. 11-49. "Oilwell" representatives will gladly supply any engineering data you may desire. Names and locations of pump installations will be furnished upon request.

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USS "OILWELL"

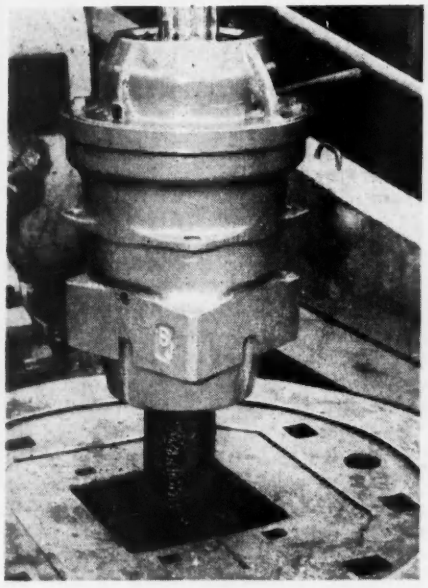
UNITED STATES STEEL

NEW AND IMPROVED EQUIPMENT

SUPPLEMENTING COMPOSITE CATALOG

267—Kelly Bushing

This item supplements Byron Jackson Company data as shown on pages 901-1000 of Composite Catalog, 17th Edition.



Body of the new BJ "B" kelly drive bushing is of solid one-piece construction. An oil resistant inner cushion fits the corrugated bore of the body to absorb the shock and assure a silent drive as the kelly rotates.

A slip retaining ring provides a positive lock and quick method of changing the kelly bushing to fit all sizes of square kellys from 3 to 6 inches, inclusive.

The bushing has 2 kelly wipers, one at top and one at bottom, which retain the grease within the bushing, providing constant lubrication between the kelly and liner surfaces at all times. The wipers also prevent all foreign matter, some of which contains abrasive material, from entering the bushing. Liners are available in either steel or aluminum bronze.

For additional information, write Byron Jackson Company, P. O. Box 2017, Terminal Annex, Los Angeles 54.

268—Supercharger

This item supplements The Cooper-Bessemer Corporation data as shown on page 1280 of Composite Catalog, 17th Edition.

Superchargers of size and design to handle requirements of any gas or diesel engine from 1200 to 2500 horsepower are made especially for Cooper-Bessemer type LS and LSV engines.

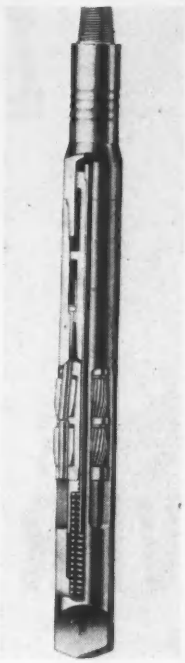
An effective means of increasing engine power output without increasing the size or speed of the engine, supercharging is particularly adapted for use where weight is of prime importance. Through increasing the intake or manifold pressure of an engine by means of a supercharger, it is possible to inject and burn more fuel in the cylinder and boost the output as much as 100 percent.

For additional information, write The Cooper-Bessemer Corporation, Mt. Vernon, Ohio.

269—Underreamer

This item supplements Grant Oil Tool Company data as shown on pages 1849-1872 of Composite Catalog, 17th Edition.

A new underreamer of the roller cutter type performs with efficiency in soft strata, although especially designed to cut into hard and abrasive formations normally requiring rock bits.



The tool has a positive expanding action and a cutting capacity that together assure full gauge hole. Expansion of cutters allows retention of a sheath of cement around the casing shoe sufficiently thick to insure effective water shut-off.

The underreamer does not need to be taken out of the hole to reset the cutter assemblies.

All metal parts are construction of alloy steel, heat-treated to yield maximum performance. All seals are of oil-resistant materials.

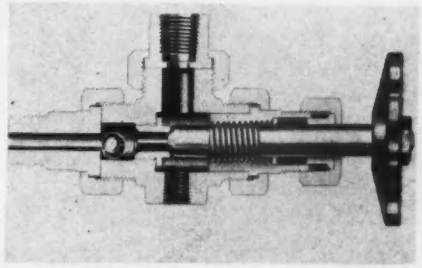
For additional information, write Grant Oil Tool Company, 2042 East Vernon Avenue, Los Angeles 58.

Save Time—Write Direct

As a service to readers, all items in WORLD OIL include the complete mail address of the manufacturer. This makes it possible for those desiring additional information to write any manufacturer without the delay occasioned by going through offices of WORLD OIL, and enables subscribers to request specific data in which they are particularly interested.

270—Double Union Valve

This item supplements Jerguson Gage & Valve Company data as shown on page 2553 of Composite Catalog, 17th Edition.



Union connection to both the gauge and the tank or vessel makes it possible to turn the gauge of a new double union gauge valve in any desired angle, or quickly remove it without removing the valves or draining the liquid from the vessel. Three new double union models are available, including two offset valves, 66-U and 46-U, and a steam-jacketed globe type valve, 93-U.

The offset valves are designed with a body which has gauge and vent or drain connections, offset 7/8-inch so the interior of the flat glass gauge may be cleaned without removal of the gauge. These are also used on side-connected gauges to gain maximum visibility between fixed centers.

The steam jacketed globe valve eliminates the necessity of costly steam tracing, and is available either with or without a stainless steel barrel check safety shutoff.

All types are available either plain or quick-closing, with stainless steel trim, and interchangeable unions, nuts and tailpieces.

For additional information, write Jerguson Gage & Valve Company, 80 Fellsway, Somerville 45, Mass.

271—Fuel Treatment

This item supplements American Sand-Banum Company, Inc., data as shown on page 342 of Composite Catalog, 17th Edition.

A flash point of more than 200° F. is claimed for Sabanol, homogenizing fuel oil treatment. The chemical disperses sludge and water in the oil, provides colloidal homogenization of sludge and emulsification of water in all grades of fuel oil, the manufacturer states.

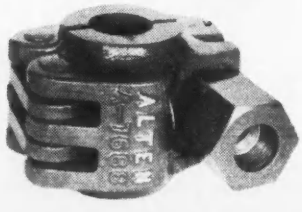
A neutral, concentrated liquid fuel oil treatment, Sabanol contains soot retardant and rust inhibitor which are also effective in all grades of fuel oil.

It is non-toxic and non-explosive.

For additional information, write American Sand-Banum Company, Inc., 9 Rockefeller Plaza, New York 20, N. Y.

ALTEN EQUIPMENT

THE WORLD OVER



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LANCASTER, OHIO, U. S. A.

ALTEN

NEW EQUIPMENT
SUPPLEMENTING COMPOSITE CATALOG

272—Time Recorder

This item supplements Warren Automatic Tool Company data as shown on pages 4910-4913 of Composite Catalog, 17th Edition.

Time required for trips, number of stands, down time, drilling rate and other information is automatically recorded on a strip chart by Rig Runner. All drilling operations are related to the various positions of the traveling block.

There are no cranks, levers or clutches for the driller to operate. A few notes and comments written directly on the chart provide a comprehensive drilling report. Each chart roll is sufficient for more than 2 weeks of continuous operation, but the chart can be torn off daily if desired without losing the continuity of the record.

Warning and signalling horns are also provided. A low pitched warning notifies the driller of routine operations, as, for example, when the third tool joint passes through the rotary on trips out of the hole. A high-pitched horn signals the entire crew when the block approaches dangerously close to the crown.

For additional information, write Warren Automatic Tool Company, 1920 Hussion Street, Houston.

273—Deviation Surveyor

This item supplements A-1 Bit & Tool Company data as shown on pages 97-120 of Composite Catalog, 17th Edition.

A deviation surveying instrument that can be easily transported from one rig to another, the A-1 "Tool Pusher Model Sure Shot" deviation recording instrument is similar to the Model B Sure Shot, except that the outer barrel and shock

absorber are in 2 pieces each, instead of the 1-piece units.

The instrument is enclosed in a 40 x 16-inch carrying case which will fit in either the trunk compartment or between the seats of an automobile.

For additional information, write A-1 Bit & Tool Company, P. O. Box 2133, Houston 1, Texas.

274—Diesel Engine

This item supplements General Motors Corporation, Detroit Diesel Engine division, data as shown on pages 1366-1369 of Composite Catalog, 17th Edition.

Designated the "110" because of its 110-cubic inch displacement per cylinder, a new compact, light weight diesel engine is a 6-cylinder, 2-cycle unit rated at 275 horsepower.

Horsepower rating of 275 at 1800 revolutions per minute is attained with a brake mean effective pressure of 92 pounds per square inch. Bore is 5 inches and stroke, 5.6 inches.

The engine uses blower scavenging with a new gear-driven centrifugal

blower furnishing considerably more air for the cylinders than is needed for combustion. The blower is located at the rear of the engine, above the flywheel. Blower impeller is an aluminum alloy forging 9 inches in diameter, of the open type with radial vanes.

GM unit injectors (one for each cylinder) pump, meter and atomize the fuel.

Cylinder block and head are one-piece castings, both symmetrical about a vertical plane between the No. 3 and 4 cylinders. All wearing parts of the engine, such as cylinder liners, bearings, valve guides and inserts, are readily replaceable.

Forced feed lubrication is used, with a gear-driven pump delivering 45 gallons per minute at 1800 rpm.

The "110" is available as a bare engine, with full equipment for marine or industrial use, or with special accessory arrangements.

For additional information, write Detroit Diesel Engine division, General Motors Corporation, 13400 West Outer Drive, Detroit 28, Mich.

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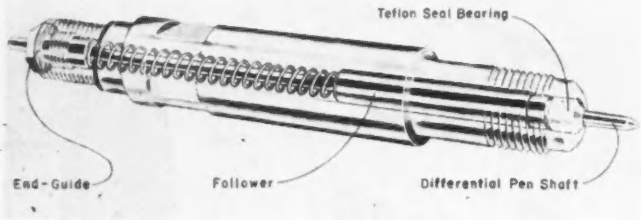
THE RIDGE TOOL CO. • ELYRIA, OHIO

275—Meter Stuffing Box

This item supplements Pittsburgh Equitable Meter Division data as shown on pages 4104-4107 of Composite Catalog, 17th Edition.



The heart of a new orifice meter stuffing box is a combination packing and bearing machined from a new synthetic plastic known as Teflon, whose important qualities are its waxy surface and its cold flow under pressure.

A spring-loaded follower sleeve compresses the Teflon bearing in a packing gland. The Teflon flows very slightly, acting like a packing material and adjusting itself to the stuffing box body and to the periphery of the shaft. Lubricant as a sealing medium is not necessary, but can be applied to the shaft without harming its performance. Factory tests of this design without lubricant showed no leakage under high pressure, and the shaft rotated freely under a torque of only 9.7 inch-grams.

Packaged kits comprised of a new stuffing box and appropriate compensating links and pen arm are available for converting meters already in service.

For additional information write Pittsburgh Equitable Meter Division, Rockwell Manufacturing Company, Pittsburgh 8.

276—Rod Rotor

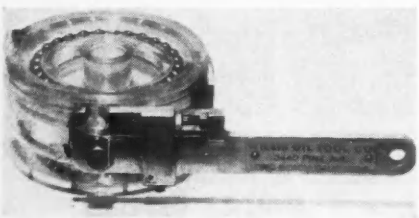
This item supplements Willis Oil Tool Company data as shown on pages 5052-5053 of Composite Catalog, 17th Edition.

The Willis rod rotor, adaptable to all makes of pumping units, is essentially an annular thrust ball bearing with an ultimate load capacity of 700,000 pounds. The lower half of the bearing rests on the standard carrier bar of the pumping unit and the upper half forms a table on which the polish rod clamp rests. In between is a floating ring containing ball clutches mounted so as to give rotary motion to the upper member. Additional ball clutches in the lower half act as holding clutches and prevent the table from backing up.

The operating lever, mounted on a needle bearing and actuated by an adjustable pull rod from the horsehead, is provided with an adjustable jaw by means of which the rate of rotation can be changed to suit the operator.

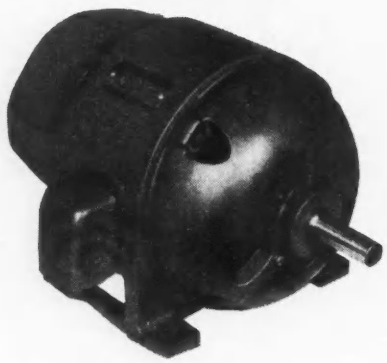
The rod rotor was designed for the purpose of reducing maintenance costs in pumping wells by preventing grooving of the polish rod by the stuffing box, distributing wear evenly on the sucker rods and the rod boxes, on the pump barrel and the plunger, by preventing the rods from backing out of the rod boxes, and by operating paraffin scrapers.

For additional information write Willis Oil Tool Company, 3440 Pine Avenue, Long Beach 7, Calif.



277—Single-Phase Motor

This item supplements General Electric Company data as shown on pages 1809-1820 of Composite Catalog, 17th Edition.



For use where a constant-speed high-torque single-phase motor is required in large ratings, a new repulsion-induction motor combines the high starting torque of the repulsion motor with the constant-speed characteristics of the induction motor.

Designated as Type SCR, the motor is available in 5-, 7½-, and 10-horsepower ratings, all 1800 revolutions per minute. The 5 horsepower unit operates on 115/230 volts, while the other two use 230 volts.

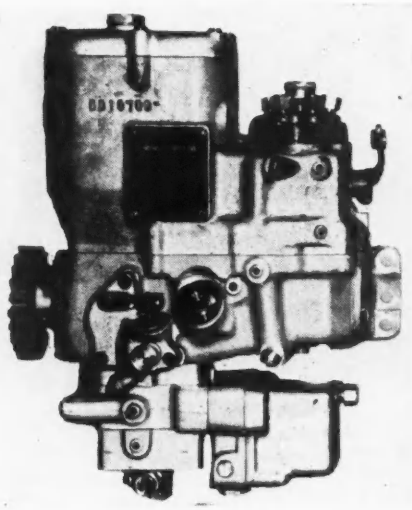
The motor is of the open (drip-proof) type. Tri-Clad construction affords triple protection against physical damage, electrical breakdown, and operating wear and tear. The cast-iron frame has a damping effect on noise and vibration.

To assure good alignment between stator and rotor, ball bearings are mounted directly in the end shields of the new motor. Efficient cooling is provided by a single large-diameter cast-aluminum fan.

For additional information, write General Electric Company, Apparatus Department, Schenectady 5, N. Y.

278—Fuel Pump

This item supplements Cummins Engine Company, Inc., data as shown on pages 1293-1312 of Composite Catalog, 17th Edition.



A new fuel pump, 65 percent lighter in weight and 56 percent smaller in size than the previous Cummins model is now offered as standard equipment on 300 horsepower model NFRS-600 and 275 horsepower NHS-600 Cummins diesels. The DD (double-disc) pump is simple to install and maintain, and reduces the over-all weight of Cummins diesels, the manufacturer states.

A tandem arrangement of the DD pump is standard on the 12-cylinder, 400 horsepower, model NVH-1200, and 550 horsepower NVHS-1200.

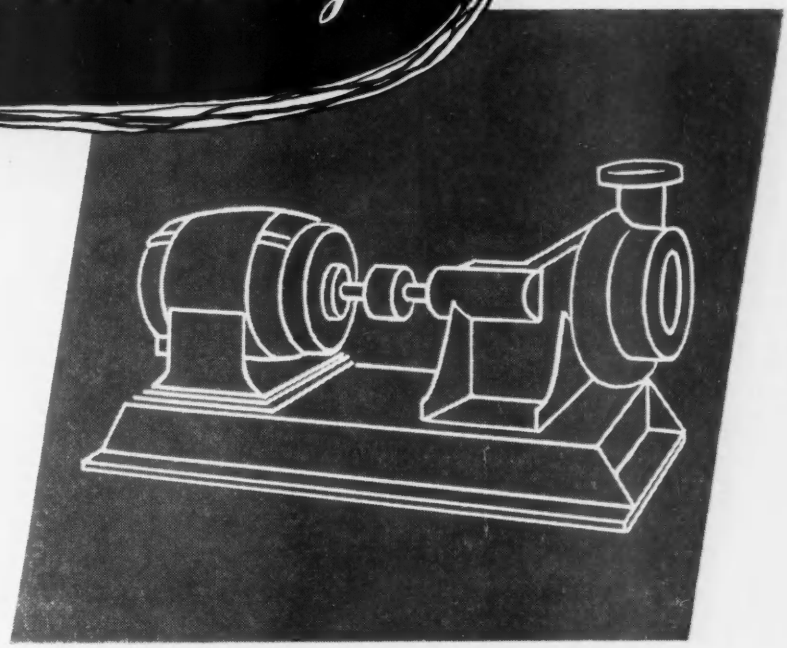
Unit replacement of fuel pressure pumps, distributor discs, and governor assembly is possible without removal of the pump from the engine. Alignment in the servicing of the pump is minimized as all parts and the bearings in which they rotate are included in the same housing.

For additional information, write Cummins Engine Company, Columbus, Ind.

25 Centrifugal Pump

MANUFACTURERS HAVE THEIR CATALOGS

FILED IN *Composite Catalog*



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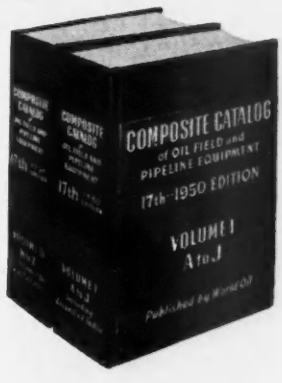


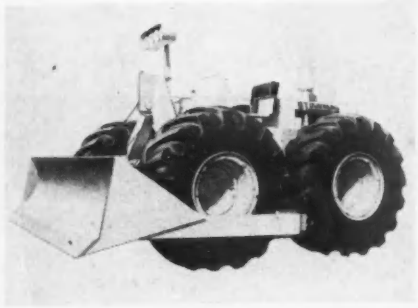
THE UNIVERSAL EQUIPMENT GUIDE FOR OIL COUNTRY BUYERS

COMPOSITE CATALOG

DESCRIPTIONS OF NEW EQUIPMENT IN THIS ISSUE OF WORLD OIL ARE SUPPLEMENTS TO THE MANUFACTURERS' PRE-FILED CATALOGS IN THE COMPOSITE CATALOG

OTHER NEW AND IMPROVED EQUIPMENT

279—Tractor Dozer



The Super D Tournadozer is a speedy, rubber-tired, 4-wheeled tractor dozer for jobs which do not require the use of the standard size dozer. It is about 3500 pounds lighter, with a smaller capacity bowl (1.8 yards), and powered by a 122 horsepower diesel engine. It has 4 speeds forward up to 19 mph, with 2 reverse speeds.

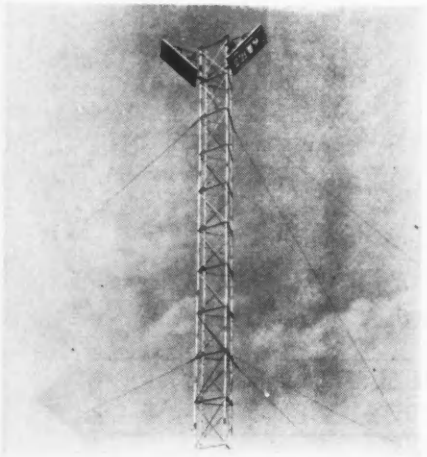
Over-all specifications of the Super D are: wheelbase, 5 feet 11⅝ inches; length, 15 feet 2 inches; height, 8 feet 1 inch; width of blade, 11 feet 3 inches; height of bowl, 36 inches; height blade can be raised above ground, 44 inches; distance blade can be lowered, unlimited.

For additional information write R. G. LeTourneau, Inc., Peoria, Ill.

280—Relay System

A new microwave relay system has double frequency modulation sub-carrier type multiplexing, passive flat reflector antenna systems with all electrical components, including the complete radio frequency assembly installed at ground level, and built-in test equipment and terminal facilities for telephone, teletype, telegraph, telemetering, and supervisory control circuits.

The standard systems are set up for 1 to 5 and 5 to 10 channel operations, a standard 10-channel model capable of transmitting and receiving up to 10 normal voice circuits, 180 teletype circuits, 400 remote supervisory control functions, or innumerable combinations of these.



For additional information write Motorola, Inc., 4545 West Augusta Boulevard, Chicago.

281—Derrick Barge

A YD derrick of the steel A-frame type, mounted on a steel barge 160 feet long, 60 feet wide, and 14 feet deep, is available for off-shore operations on the Gulf Coast and the Pacific Coast. Steam powered and adequately equipped with

living quarters and auxiliary equipment, it requires a lifting capacity of 150 tons on the main fall blocks and 75 tons on each of the two side blocks. It is capable of lifting up to 200 tons.

For additional information write Johnson Western Company, San Pedro, Calif.

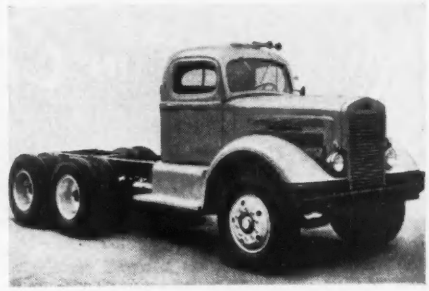
282—V-Belt Idler

A V-belt idler for driving pumps from the engine flywheel is so inclined that the idler pulley can travel midway between the faces of driver and driven pulleys at all elevations.

It takes up belt stretch without sliding base and flexible connections. Slightly shorter centers than indicated for a standard belt length allow belts to move easily, while the use of one belt length longer than standard gives more belt contact, permits running with slacker belts, which is easier on belts and bearings.

For additional information write Ashcraft Idler Company, 2926 Gilroy Street, Los Angeles 39.

283—Truck



A foreshortened front end which permits a desirable weight within legal limits, especially in states employing the bridge formula for computing truck weights, is an important feature of two new model White trucks. Aluminum disc wheels save 37 pounds per wheel, and a tandem drive gives extra payload capacity and more power for heavy hauling jobs, the manufacturer states.

Model WC-2264-ET has a 154-inch wheelbase and a 135 horsepower engine. Model WC-2864-ET weighs 12,210 pounds, has a 152-inch wheelbase and a 184 horsepower engine.

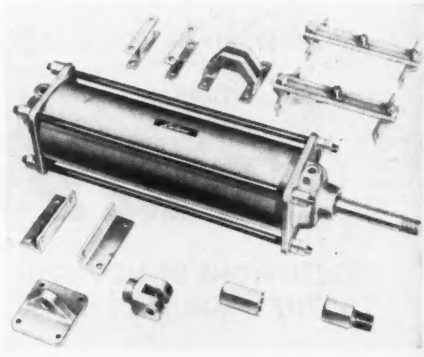
For additional information write The White Motor Company, Cleveland 1.

284—Cylinders

Tie-rod construction of new medium duty air and hydraulic cylinders gives positive protection against leakage at joint of tube and head. Chevron packing seals the piston rod. Synthetic cups and automatic cushion are standard. Like the heavy duty and super duty lines which they supplement, they are for use in alll industries involving the use of straight line motion.

These cylinders are manufactured to standardized design, with various head and rod attachments for most mounting requirements.

For additional information write Ledeen Manufacturing Co., 1600 South San Pedro Street, Los Angeles 15.



OTHER NEW EQUIPMENT

285—Grounding Reel

The Series 200 Benjamin portable grounding reel is used in connection with the generation of static charges on fuel servicing equipment during the transfer of combustible fuels. The cable is paid out or retracted as desired, and the grounding cable is kept off the ground.

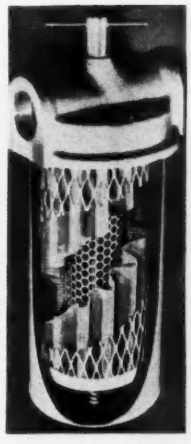
The reel is equipped with 20 feet of

3/32-inch diameter phospher bronze cable and a 1-foot phospher bronze pigtail to fasten to the ground connection. It is available in an overhead model for fastening to ceiling or wall, and a model for field installation equipped with an adapter to secure it to a ⅝-inch diameter grounding rod.

For additional information write Benjamin Reel Products, Inc., 10700-10710 Broadway, Cleveland 5.

286—Filter

The Marvel synclinal filter is available in a liquid line model for insertion into any pipe carrying non-corrosive liquids. Adaptable to any position, the filter, with its synclinal design, provides a large filtering area in a small amount of space.

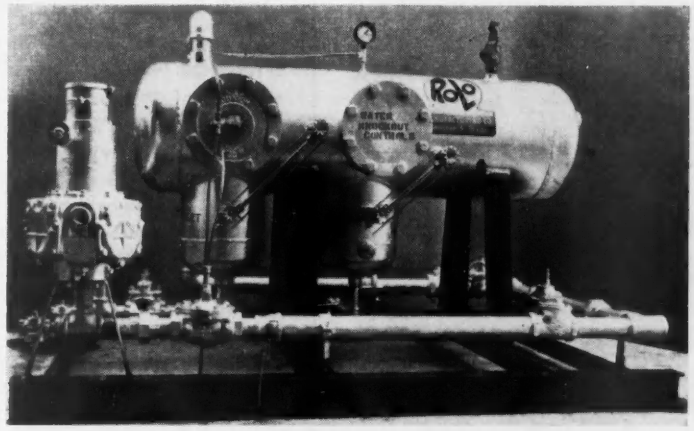


Adaptability to meet individual filtering requirements is furnished by a variety of wire mesh ranging from a coarse 30 to a fine 200. Capacity sizes are 5, 8, 10, 20, 30, and 50 gpm. Greater capacities may be obtained by multiple installations.

For additional information write Marvel Engineering Company, 625 West Jackson Boulevard, Chicago 6.

ROLO WELLCHECKERS

NEW LOW-COST OIL AND GAS SEPARATOR



Rolo No. 4—1H-1604 - Skid or Trailer Mounted

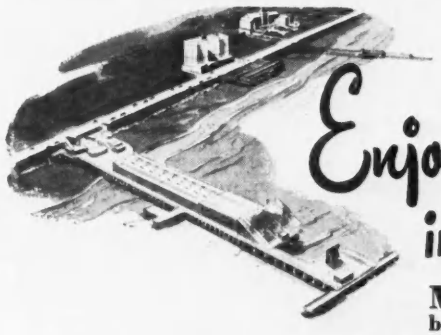
This unit has a separator 16" x 4' x 125# w.p., API-ASME code-labelled to handle prorated wells and small strippers. It efficiently handles from 5 to 500 bbls. per day with a maximum of 200,000 cu. ft. of gas. May be equipped with automatic water knockout, where free water is prevalent. Designed to sell for considerably less than $1000 (completely piped with oil meter), this unit enables the operator to check his well production daily and to secure accurate records for royalties and taxes. Rolo Wellcheckers are made in all sizes to fit any operation. See Composite Catalog or write for illustrated Bulletin.

Oil Well Metering Specialists

ROLO MANUFACTURING COMPANY

BRANCHES: Corpus Christi, Midland, Kilgore, Tulsa, New Orleans, Casper, Edmonton, Alta.

EXPORT OFFICE: R. S. Stokvis & Sons, Inc., 17 Battery Place, New York, N. Y.



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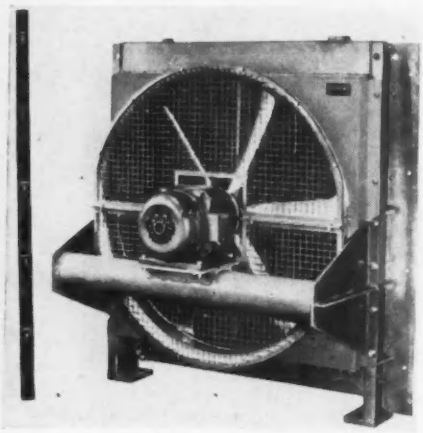
TEXAS
HOTEL STEPHEN F. AUSTIN.....Austin
HOTEL EDSON.....Beaumont
HOTEL BROWNWOOD.....Brownwood
HOTEL BAKER.....Dallas
HOTEL TRAVIS.....Dallas
HOTEL CORTEZ.....El Paso
HOTEL TEXAS.....Fort Worth
HOTEL BUCCANEER.....Galveston
HOTEL GALVEZ.....Galveston
HOTEL JEAN LAFITTE.....Galveston
CORONADO COURTS.....Galveston
JACK TAR COURT HOTEL.....Galveston
MIRAMAR COURT.....Galveston
HOTEL CAVALIER.....Galveston
HOTEL PLAZA.....Laredo
HOTEL LUBBOCK.....Lubbock
HOTEL FALLS.....Marlin
HOTEL CACTUS.....San Angelo
HOTEL MENGER.....San Antonio
ANGELES COURTS.....San Antonio

VIRGINIA
HOTEL MOUNTAIN LAKE..Mountain Lake
HOTEL MONTICELLO.....Norfolk

287—Radiator



New design details for jacket water cooling radiators, have been incorporated into special Monoweld radiators to produce a unit that is practically corrosion resistant. All major ferrous parts are zinc plated, and nuts, bolts, screws, and washers are cadmium plated. The actual core and cooling parts are of corrosion-resisting copper, brass, and aluminum.

Other construction details include welded steel tanks, side members, and motor base supports, a cast aluminum air foil fan, and an aluminum fan shroud with aero-dynamically designed venturi type opening.

Designed to maintain a maximum jacket water temperature of 180° F. with a maximum of 120° F. ambient air temperature, the radiator will cool a 173 hp diesel engine running at 720 rpm driving a 100 kw generator.

For additional information write Young Radiator Company, Racine, Wis.

Save Time—Write Direct

As a service to readers, all items in WORLD OIL include the complete mail address of the manufacturer. This makes it possible for those desiring additional information to write any manufacturer without the delay occasioned by going through offices of WORLD OIL, and enables subscribers to request specific data in which they are particularly interested.

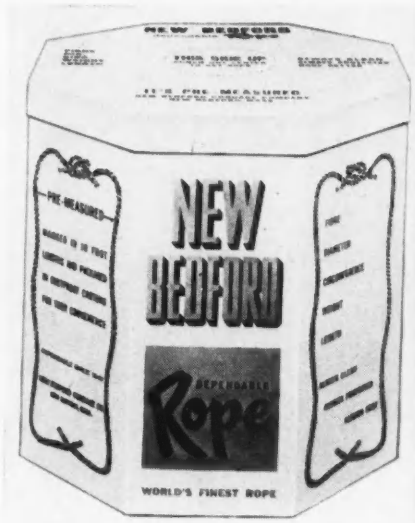
288—Valve Insert

A new valve seat insert meets all size specifications for internal combustion engines.

The allow used in the valve seat is free from checking and burning under extreme temperatures. Due to the density of the material, the seats have the faculty of dissipating the heat trapped in the valve and materially reduce valve temperatures, the manufacturer states.

For additional information, write Martin Wells, Inc., 5886 Compton Avenue, Los Angeles 1, Calif.

289—Rope Container



A new corrugated self-dispensing container for rope coils keeps the rope clean at all times and serves as a handy storage unit for the unused portion of the coil. The flat-topped container takes little room and is easily stacked. Clearly marked with size and fibre, it eliminates rope tangling and snarling since it can be opened only at one end.

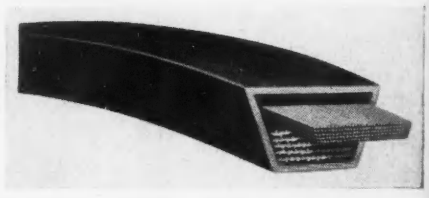
Pre-measured package rope, factory marked in red at 10-foot intervals, is available in 6 sizes ranging from 3/16 inch to ⅞ inch in diameter.

For additional information write New Bedford Cordage Company, New Bedford, Mass.

290—V-Belts

The new "HY-T" line of V-belts uses a chemically-produced fibre of extremely high strength with excellent shock-absorbing qualities, and inherent resistance to shrinking.

It is claimed that these belts can handle 40 percent more horsepower than



standard multi-V-belts without excessive stretch.

The new synthetic cord is water and mildew resistant, and the materials forming the outside covering of the HY-T have been treated with a mildew inhibiting agent.

For additional information write Goodyear Tire & Rubber Company, 500 South Main Street, Akron, Ohio.

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Chicago & Southern Air Lines' fleet of 4-motored Douglas Skymasters now offers seven-days-a-week service through the Houston and New Orleans gateways to Caracas, Kingston, and Havana. Flights each way every day provide one-plane service from the Great Lakes to the Venezuelan oil capital. Ask your travel agent or nearest C&S ticket office.

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C★S

NEW LITERATURE

291—Geophysical Tools

Catalog pages of interest to oil operators and geophysicists describe and illustrate new geophysical equipment. Magnetic core analyser, porosity indicator, electronic gravity meter, radio location system and electric micrometer are treated.

For a copy of these pages write Petroleum Engineering Corporation, 122 South Michigan Avenue, Chicago.

292—Motors

A new bulletin on polyphase electric motors describes 1- to 75-horsepower horizontal motors, illustrating construction details in cross section and cutaway views.

For a copy of Bulletin EM4-812 write A. O. Smith Corporation, Milwaukee, Wisconsin.

293—Valves

All current models of Falcon-Greenwood valves are presented in a new 12-page colored catalog. Complete specifications, prices, and installation recommendations are included.

For a copy of this catalog write Falcon Products, Inc., 949-969 East Second Street, Pomona, Calif.

294—Well Equipment

Catalog C-60 lists and illustrates Larkin's entire line of packers, bailers, sand pumps, and other equipment incident to secondary recovery.

For a copy of this catalog, together with Price Book 60 and discount sheet, write Larkin and Company, Inc., Butler Penn.

295—Welding Process

A new descriptive folder on the recently introduced Aircomatic welding process tells the Aircomatic story in a concise manner, covering such topics as operation, features of the process, manual and automatic equipment. The illustrations include photographs of work done with this new process.

For a copy of this folder write Air Reduction, 60 East 42nd Street, New York 17.

296—Diesel Engines

Bulletin 5291 gives complete specifications of all automotive and industrial models of HR-400 Cummins Diesels.

For a copy of this bulletin write Cummins Engine Company, Inc., Columbus, Indiana.

297—Swivel Bail

An 8-page bulletin covers a new connector-type swivel bail which simplifies and streamlines the drilling string. Construction features are described and illustrated.

For a copy of Bulletin I-363 write The National Supply Company, Box 899A, Toledo.

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GOTKOOL WATER COOLER
Made in 2, 3, 5, 8, 10, 15 and 20 gallon sizes with Push-Button Faucet.

GOTT Water Coolers are the convenient way to keep drinking water handy to the worker, protect it from impurities. Their exclusive construction keeps water cool for long periods. Snug fitting large removable top, handy non-leaking push button faucet. GOTT Water Cans for handy field use. Your Supply Store has them, get one today! . . . .

GOTKOOL WATER CAN
Made in 1½, 2, 3, 5, 10, 15 and 20 gallon sizes. (Push-Button Faucet at slight additional cost.

H. P. GOTT MFG. CO.
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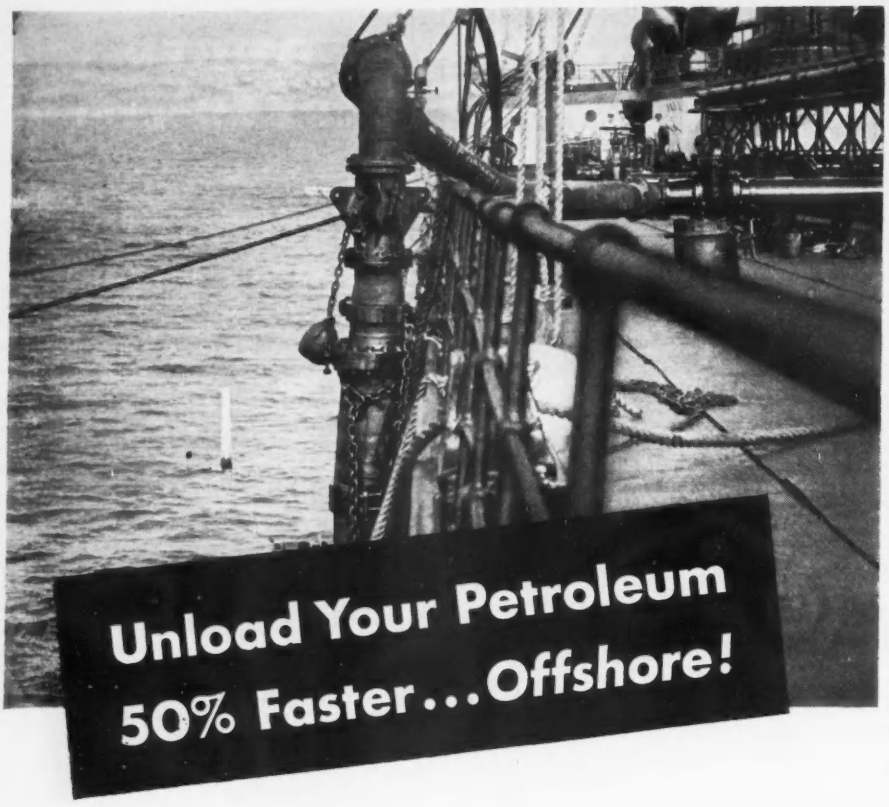
KEEP PURE DRINKING WATER ALWAYS HANDY



Where there aren't dock facilities, there are serious problems—especially for hose. Service is long-haul, pressure terrific, flexing constant. On the inside is a procession of petroleum products, on the outside are salt water and sand—all of them capable of imposing serious damage.

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FINALLY, there is much longer life. A high-tensile bead-wire reinforcement gives strength to withstand tremendous pressures—yet assures ample flexibility to withstand constant flexing. Its extremely tough and thick cover is unharmed by constant submersion and the abrasion of rolling over sandy ocean bottoms. This cover cannot strip. Nor will the smooth-bore tube pull out; it's bonded securely to the carcass and cured to the nipple to prevent leakage.

For fastest off-shore delivery at lowest cost, specify Hewitt-Robins Monarch® Sea-Loading and Submarine Hose. Write Hewitt Rubber Division, 240 Kensington Ave., Buffalo 5, New York, or Export Dept., Hewitt-Robins Inc., 370 Lexington Ave., New York 17, N. Y. Cable address: HEWRUB, New York.

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WATER HOSE • PROPANE-BUTANE HOSE FOR HANDLING LIQUEFIED PETROLEUM GASES
CONVEYOR BELTING • PIPE SLINGS • RUBBERLOKT® WIRE WHEEL BRUSHES

NEW LITERATURE

298—Bitology

A new 24-page illustrated brochure discusses the jet principle in rotary drilling. Proper application of jet bits, pump capacities for various horsepower ratings on all types of power pumps, and information on how to calculate horsepower for steam pumps are included.

For a copy of this brochure write A-1 Bit & Tool Company, P. O. Box 2133, Houston 1.

299—Cut-Out Switch

Bulletin CS-50 describes the working principles of the cut-out switch, which shuts down the prime mover on the pumping unit when any part of the machine fails or gets out of adjustment. Examples and installation diagrams for the switch on any make of pumping unit are given.

For a copy of this bulletin write International Derrick & Equipment Company, P. O. Box 1331, Dallas 1.

300—Pumping Units

Crank counterweighted pumping units, with type A cranks for heaviest loads, are presented in a new 20-page, 4-color, illustrated bulletin. Four basic pumping units covering API walking beam ratings from 20,700 to 32,400 pounds are described.

For a copy of Bulletin 337 write The National Supply Company, Box 889A, Toledo.

301—Heating Unit

A new heating unit that can be used interchangeably as a steam boiler or hot water heater by adapting the control equipment accordingly is described in an 8-page bulletin.

For a copy of this bulletin write Black, Sivalls, and Bryson, Inc., 720 Delaware, Kansas City 6, Mo.

302—Line Separator

Bulletin 101, a 4-page, 2-color folder, explains the Peerless line separator principle. Illustrations include a cutaway view of a line separator, and pictures of typical installations.

For a copy of this bulletin write Peerless Manufacturing Company, P. O. Box 7193, Dallas.

303—Cement

A 20-page, 2-color booklet describes the origin, the development during the past 10 years, and the varied applications of Duraplastic air-entraining cement.

For a copy of this booklet write Universal Atlas Cement Company, 723 Chrysler Building, New York 17.

Men in the Industry NEWS

Lawrence J. Vittrup

Lawrence J. Vittrup was made division geologist of South Texas division, Producing department, The Texas Company. He succeeds **Dr. S. A. Berthiaume,** who was promoted to senior geologist in the general manager's office, Producing department. **Otis B. Hocker** was named assistant manager of the Geophysical division, Producing department.

Vittrup received a B. S. degree in geology from Oklahoma University, and started with the company as a rotary rig helper in 1933. After serving in various capacities, he became a subsurface geologist in the Corpus Christi district in 1937. He enlisted in the Corps of Engineers in 1942 and served in the China-Burma-India theater during most of the war, attaining the rank of major before his discharge. In 1946 he returned to Texaco as a geologist and was advanced to senior geologist in 1948.

Berthiaume took a B. S. degree in geology from the University of Washington, and a Ph. D. degree from Cornell in 1938. He remained as an instructor at Cornell until 1940 when he joined The Texas Company at Houston as a geologist. He had been division geologist, South Texas division, since 1948.

Hocker was graduated in electrical engineering from Texas A. and M. College in 1932 and joined The Texas Company as computer on a seismic crew at Houston in 1935. He was physicist and party chief on a seismic crew in Egypt when war stopped the work in 1940. He served in the Signal Corps of the Army Air Force, receiving his discharge in 1946 as a lieutenant colonel. He joined Texaco at Houston in 1948 as a supervisor of field operations, and the following year was appointed geophysicist on the staff of the general manager, Producing department.

•

Harris Bateman leaves the position of coordinator of purchasing for Cities Service Oil Company (Del.) New York, to become chief engineer for Cities Service Oil Company (Del.) and Cities Service Pipe Line Company, and a director of Cities Service Oil Company.

Joseph Coates

Joseph Coates, senior geologist of Burmah Oil Company, has retired after 25 years with the company. In recent years he has been engaged, largely in a supervisory capacity, in exploration work, with headquarters for the past 1½ years in New Delhi. He joined BOC's geological staff in 1923 after obtaining a 1st Class Diploma at the Royal School of Mines, London, England.

•

Dr. Rycroft G. Moss has resigned as reservoir and pool geologist for Phillips Petroleum Company, Oklahoma City, to become a consulting geologist and evaluation engineer.

•

E. W. Fosshage has resigned as chief geologist for Shamrock Oil and Gas Company, Amarillo, Texas, to form the Plotted Stratigraphic Sample Log Service covering the Texas Panhandle.

KING TYPES "XV" AND "PXV" SWIVELS

FOR GEOPHYSICAL AND SHALLOW WELL DRILLING

King Type "XV" Extra Volume Swivels

These light, *Extra Volume* swivels are designed especially for exploration and shallow well drilling where it is desirable to circulate larger volume of fluid than is possible with more conventional models.

Type "XV" swivels come in four sizes with oversize watercourses ranging in diameters from 1½ inches to 3 inches, ideally adapted to every shallow drilling requirement.

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Ample thrust capacity with radial stability

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King Type "PXV" Swivel

L-K 110-VOLT ELECTRIC OIL SAMPLE HEATER

Patented

This heater fulfills a sustained demand for an efficient means of electrically heating oil samples in laboratories, pumping stations, loading racks and similar places. It is easily installed by simply connecting the lead wires to any 110 Volt line, A. C. Unless otherwise requested it comes with thermostat set for 160° F. Can be furnished for direct current on special request.

The heater embodies the following features: explosion proof; thermostatically controlled; adjustable dry heat; two models; one for 15 CC API tubes; one for 100 or 200 CC ASTM tubes; furnished with or without covers. K. W. Rating 200 Watts. Additional information on request.

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EXPERIENCED PRACTICAL AND TECHNICAL CONSULTING PRODUCTION ENGINEERING SERVICE

•

SPECIALIZING in MODERN SECONDARY RECOVERY

MEN IN THE INDUSTRY NEWS

1000th Certificate of Completion in the course, Treating Oil Field Emulsions, is presented to J. H. Nelson (right), roustabout foreman for Humble Oil & Refining Company, Kilgore, Texas, by C. J. Mosley, University of Texas instructor. The course is sponsored by API Division of Production.

Hugh R. Brankstone has been appointed employe relations advisor at the Fort Worth Production division of Gulf Oil Corporation. Brankstone was graduated from the University of Pittsburgh in 1930 with a degree in geology, and that year joined Gulf as a member of the general office Geological department. In 1947 he was named assistant to the employe relations advisor of the Production and Pipe Line department.

Hugh R. Brankstone

Gulf has created 3 staff positions in the executive department, Fort Worth, as follows: **F. C. Anderson, E. E. Merkt, Jr.,** and **K. E. Rotegard,** to be accounting, technical and economic advisors, respectively, to the vice president.

Also announced are the following promotions and new titles: **B. E. Thompson,** formerly assistant superintendent of production, to division production supervisor; **C. D. Cordry,** formerly chief zone geologist, to division geological supervisor; **H. M. Craig,** formerly assistant to the general agent, to division administrative supervisor; **M. I. Taylor,** formerly assistant chief petroleum engineer, to division petroleum engineer.

New titles were set up for: **W. M. Lourcey,** division land supervisor; **T. W. Rhoads,** division gas and gasoline supervisor; **T. J. Dwyer,** division civil engineering supervisor; **C. S. Youngblood,** division purchasing supervisor; **W. F. Rankin,** division traffic and transportation supervisor; **T. E. Vandiver,** division safety supervisor.

•

M. E. Douglass has been elected secretary of Faultline Oil Company, succeeding **J. O. Hayes.**

Frank Frawley, formerly manager of the drilling department, Barnsdall Oil Company, has organized the Frank Frawley Drilling Company with headquarters in the Petroleum Building, Tulsa.

QUICK, ACCURATE RESULTS LESS EFFORT Curtin CENTRIFUGES

No. 3420
15 c.c. machine . . .
Cranks and heads interchangeable with 100 c.c. machines.

Simple in design . . . Ruggedly built . . . Requires no special care . . . Great Ratio and throw of crank produce required speed with no strain. Curtin Centrifuges meet all *A.S.T.M. Standard Method D-96* and *A.P.I. Code No. 25* requirements. Fully descriptive literature upon request.

W·H·CURTIN & CO.

HOUSTON . . . . NEW ORLEANS.

MEN IN THE INDUSTRY NEWS

Foster Parker

Foster Parker has been elected treasurer of the Houston Oil Company of Texas by the board of directors. He succeeds **H. W. Fairbrother,** retired.

Parker is a 1938 graduate in business administration from the University of Texas, and a certified public accountant. He was formerly with Arthur Andersen & Company, Houston.

•

B. Cooper Hyde, district geologist, **E. B. Dilley,** district landman, and **Henry E. Littlejohn, Jr.,** landman, are among the new employes of the Houston Oil Company of Texas in its new Midland, Texas, office.

Graduating from Stanford University in 1931, Hyde did graduate work in geology at California Tech. He was associated with Barnsdall Oil Company, Superior Oil Company, and the Devonian Oil Company, from which he resigned to accept his present position.

Dilley was a scout and landman with Atlantic Refining Company for many years. He had been with H. L. Hunt at Midland since 1947.

Littlejohn had been a scout and land man for Tidewater Associated Oil Company and Barnsdall Oil Company.

•

D. M. McBride

D. M. McBride has been appointed manager of the Crude Oil Purchases and Sales division of Phillips Petroleum Company. He replaces **E. F. Guidinger** who becomes consultant to the vice president in charge of supply and transportation.

McBride joined Phillips in 1929 as city sales agent in Lincoln, Neb., and was transferred to the home office at Bartlesville, Okla., in 1939. He has been assistant manager of crude oil purchases and sales since 1947.

•

R. E. O'Donnell has joined Republic Natural Gas Company as drilling superintendent, with headquarters in Dallas.

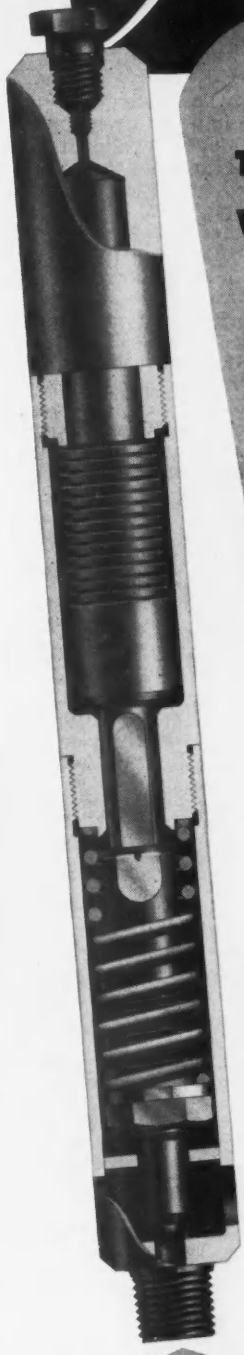
O'Donnell was formerly associated with Halliburton Oil Well Cementing Company in various capacities, the most recent of which was public relations director. Prior to his association with Halliburton he worked for a number of drilling contractors in the Mid-Continent field.

•

Harry A. Trower, after 32 years with Phillips Petroleum Company, has retired as vice president and has moved from Bartlesville, Okla., to Tulsa.

CAMCO

Gas Lift Valves



THE ONLY VALVE WITH INSURED WELL ACTION

CAMCO-IZING . . . an exclusive Camco process . . . pre-forms the Camco valve bellows with 5,000 lbs. differential pressure, testing and conditioning it for correct, positive action under the most severe well conditions. That's one of the big reasons why hundreds of CAMCO VALVES are installed today under well conditions requiring from 125 thru 1650 psi. The Camco line of gas lift equipment is the most complete offered by any manufacturer. Four general types of CAMCO Valves . . . Pressure Controlled, Differential Flow, Constant Flow and Injection Control . . . provide the widest range from which to choose the right valve for your well. Ask your Camco Representative at Corpus Christi, Alice, Victoria, Beaumont, Lafayette, Shreveport, Houma, Midland, Odessa, Oklahoma City . . . or phone, wire or write CAMCO, INC., 1108 Scanlan Bldg., Houston, about your well producing problems.

Quick facts about

CAMCO VALVES

Stress-equalized monel spring combined with pressure-charged bellows provides positive valve shut off — also makes field adjustment easy up to 100 psi above or below original setting.

Diamond-hard Tungsten Carbide ball valve minimizes fluid leakage and seat cutting, gives long trouble-free service.

Scientifically designed inlet ports and flow passages provide greater efficiency.

Your copy of the new CAMCO catalog is now ready . . . Write for it today.

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Red Top (Hydrostatic) BAILER
A QUICK, POSITIVE LOAD REGARDLESS OF FLUID LEVEL.
Ideal also for fishing small objects—widely used for drilling in (completing) wells, and for drilling cement or plastic plug overages.
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CORPUS CHRISTI, A. S. Baylor, Phone 2-2461.
WICHITA FALLS, Hudson-Eads, Inc., phone 2-8584.
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Contracts accepted for domestic and foreign projects, using the most improved instrumental and interpretative technique.
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MEN IN THE INDUSTRY NEWS

H. Gardiner Symonds

W. C. MacMillan

W. C. MacMillan, executive vice president of Continental Oil Company, and **H. Gardiner Symonds,** president of the Tennessee Gas Transmission Company, have been elected to the board of directors of Continental Oil Company.

MacMillan joined the company more than 22 years ago as an instrument man in the geological department at Shawnee, Okla., and through successive promotions became assistant land superintendent, manager of the land department, vice president in charge of production, vice president and administrative assistant to the president, and, in 1949, executive vice president.

Symonds, who received his degree in geology from Stanford in 1924 and his Master's degree with distinction from the Harvard Schoo' of Business Administration, has been president and a director of Tennessee Gas Transmission since 1943. He is also a director of the General Telephone Corporation, Mathieson Hydrocarbon Chemical Company, Sterling Oil & Gas Company, and the National Bank of Commerce, Houston.

•

Roscoe E. Shutt, formerly vice president in charge of exploration for Barnsdall Oil Company, has opened offices in Tulsa as a consulting geologist and independent operator. In addition he will act as geological consultant for Sunray Oil Corporation, which recently acquired Barnsdall.

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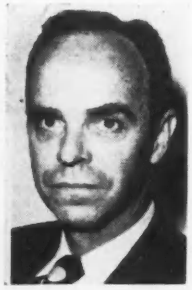
Carl B. Richardson

Carl B. Richardson has resigned as research geologist for Barnsdall Oil Company to become a consulting geologist in Tulsa. He had been with Barnsdall for 13 years, working principally with problems of regional geology. He is nationally known for his work on limestone reefs, particularly those of West Texas.

•

F. G. Hawk is acting manager of the regional purchasing-stores department, Shell Oil Company, Houston, during the absence of **O. D. Story,** who is on special assignment in New York. **A. J. Clark,** formerly supervisor of the company's purchasing-stores in the New Orleans area, is acting as assistant manager.

Trading Post Ahead—page 282

SHARES for SALE
A real opportunity to invest in 416 shares of two related successful Geophysical Corporations. Full information will gladly be supplied on request.
Write to: Box 88-WO, c/o World Oil, Houston, Texas.

Standco NO-SMOKE
STANDCO BRAKE LINING
Nothing novel—no bunk, but it gets the job done without scoring brake rims. See pages 3973-3978 Composite Catalog.
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EXCLUSIVE EXPORT DISTRIBUTOR
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You Are ALWAYS RIGHT When You STANDARDIZE on PARMACO PRODUCTS
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SEE OUR CATALOG IN COMPOSITE CATALOG
Ask Your Favorite SUPPLY HOUSE
PARKERSBURG MACHINE COMPANY
PARKERSBURG, W. VA.

Rush Greenslade, vice president and general manager of the Tulsa division, Gulf Oil Corporation and Gulf Refining Company, has resigned after 34 years of continuous service and has been succeeded by **Philip H. Bohart.** Greenslade was born in Lima, Ohio, and moved to Oklahoma in 1908 to practice law. He joined the legal department of Gypsy Oil Company in 1914 and moved to Tulsa. He was named vice president of Gypsy and also of Gulf Pipe Line Company of Oklahoma in 1926. Ten years later when the two were merged with Gulf Oil Corporation and Gulf Refining Company, he was made a vice president. As Gulf expanded Greenslade was made a vice president of Gulf Oil Corporation, the Gulf Refining Company, Canadian Gulf Company and Gulf Research and Development Company.

Bohart was in charge of Gulf's operations in Mexico before going to Tulsa and has steadily advanced in the organization, recently being elected a vice president of Gulf.

•

E. C. Bothwell, a director and vice president of Gulf Oil Corporation, has retired after 35 years of uninterrupted service with the Gulf companies. **Dr. K. C. Heald** was elected a director to fill the vacancy on the board.

As a member of one of the early Oklahoma oil firms, Bothwell pioneered in the

E. C. Bothwell

K. C. Heald

development of Glenn pool, the first great oil strike in Oklahoma. His association with Gulf dates to 1915 when he joined the Tulsa Production division. He was transferred to the company's general offices in Pittsburgh as assistant to the vice president in charge of production in 1916. He has been a vice president of the corporation and many of its subsidiaries for the past 15 years and in 1946 became the head of the foreign and domestic exploration and production activities of the company. He is a member of the company's Finance, Budget, Expansion and Policy committees.

Heald was awarded the degree of doctor of sciences by the University of Pittsburgh in 1928. He held various positions with the U. S. Geological Survey and was chief of the Oil and Gas section when he left the Survey to become associate professor of geology at Yale University. He resigned from Yale in 1925 to become chief staff geologist of the Gulf companies. In 1945 he was elected a vice president of Gulf Oil Corporation and many of its subsidiary companies. Early in 1949 he was made responsible for the company's exploration and production activities in the U. S. and Canada. He is now in charge of all Gulf's exploration and production activities.

James B. Black of San Francisco, president of Pacific Gas and Electric Company, was elected a director of Shell Oil Company. Black's election raises the number of Shell directors to 20 and introduces a business representative from the Pacific Coast to the board.

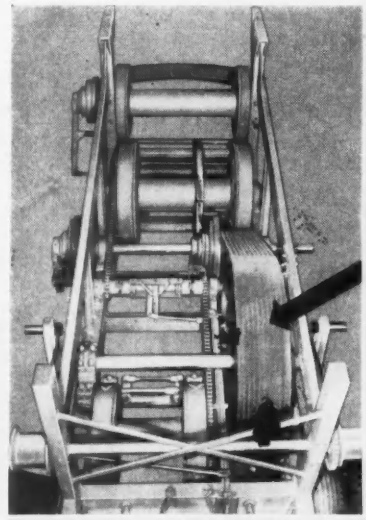
A 1912 graduate of the University of California, Black has

James B. Black

been vice president of Western Power Corporation and vice president of The North American Company. He became president of Pacific Gas and Electric in 1935.

•

James Ford, veteran oil scout for Gulf Oil Corporation at Shawnee, Okla., has retired after 30 years of service and is succeeded by **T. W. Gilmer,** transferred from Ardmore, Okla. **Dick O'Connell,** scout at Oklahoma City, will move to Ardmore and **John Remmell,** geophysical scout at Ardmore, to Oklahoma City.



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METAL
BAND WHEEL

Drilling Motion
of
Old Standard Rig
in a
Modern Machine

WRITE FOR FOLDER
GIVING FULL PARTICULARS

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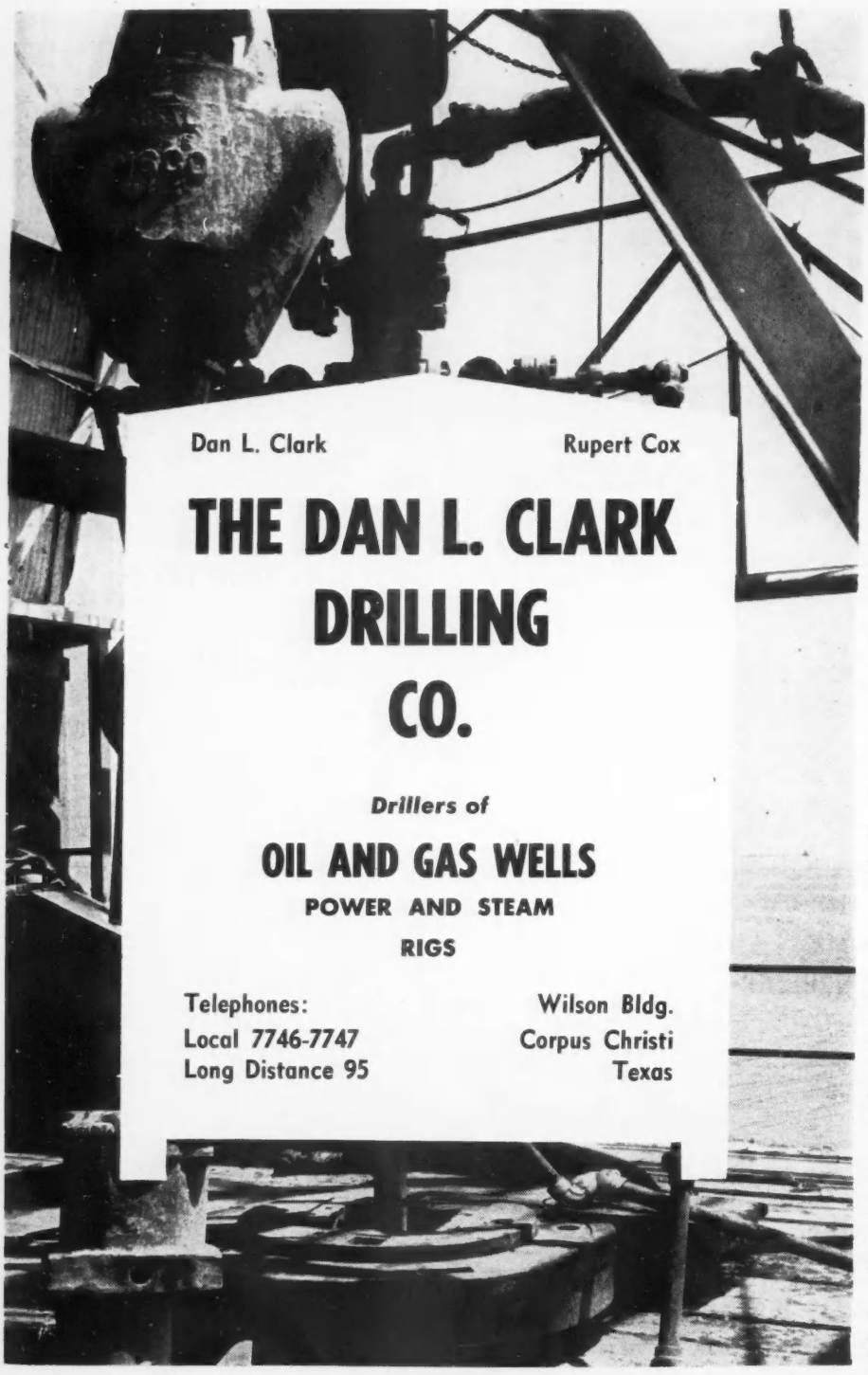
DEATHS

James Fleming Carter, Jr., 54, Tulsa, died July 14, at Tulsa. Carter was a former vice president of Gulf Publishing Company and until his retirement about 3 years ago was manager of the company's Mid-Continent district offices at Tulsa in charge of advertising, occupying that position for 25 years. He was born in Henrietta, Texas, and was a graduate of Southern Methodist University, Dallas, and a member of the Kappa Sigma fraternity. Before joining Gulf Publishing Company he had been employed in the editorial department of the Dallas News and at the time of his death was Tulsa sales representative for MacRae's Blue Book, a business directory. He was chairman of the board of trustees of the Centenary Methodist Church, and a member of the Downtown Lions Club and the Knife and Fork Club, Tulsa. Surviving are his wife, Grace; his mother, Mrs. J. F. Carter, Sr., Tulsa; 3 daughters, Mrs. Andy J. Bowden, Jr., San Francisco, Calif.; Mrs. A. R. Shell III, Plano, Texas, and Miss Mary Grace Carter, Tulsa.

•

Harry T. Wolfe, 75, pioneer Oklahoma oil operator, died July 1, at Bristow, Okla. A native of Maryland, he entered the oil business in Bristow and in 1928 sold his holdings to the Barnsdall Oil Company, but continued to operate as the Wolf Oil Corporation.



James Muir Aitken, Sr., 54, assistant manager of the Machinery & Export division of International Derrick and Equipment Company, Dallas, died in Beaumont, Texas. A graduate in commercial law of Franklin University, Aitken joined Ideco in 1926. He was a member of Nomads and API.

James Muir Aitken, Sr.

•

Richard R. Shinn, 61, general superintendent of General Petroleum Corporation's Production department, died June 18 in Los Angeles. Shinn joined General Petroleum in Taft, Calif., in February, 1913, as a production foreman. He was a member of Petroleum Production Pioneers, and was the first chairman of the San Joaquin chapter of the Production division of API.

•

C. H. Swank, 50, district superintendent, Parker Drilling Company, Brookhaven, Miss., died June 11, near Brookhaven. A native of Kansas, he had been in the oil business for 33 years and with Parker since 1936.

•

Charles B. Carpenter, 48, superintendent of the Dallas office, U. S. Bureau of Mines, died June 10 in Dallas. He had been connected with the Bureau of Mines for more than 20 years.

•

Edward M. Skeehan, 67, former vice president and treasurer of Barnsdall Oil Company, died June 26 in Van Nuys, Calif. A close friend and associate of **T. N. Barnsdall,** he went to work for him in 1906 in Pittsburgh. When the Barnsdall Corporation was formed in 1919 Skeehan became general auditor with headquarters in New York. He went to Tulsa in 1926 and was transferred from there to Los Angeles in 1932. He retired from the company 2 years ago.

•

J. J. Moroney, 82, independent oil operator and former newspaper publisher, died June 30 at Okmulgee, Okla. He engaged in the oil business in Okmulgee for 31 years after owning and publishing the Okmulgee **Democrat** from 1906-1919.

•

Charles B. Harter, 61, welding engineer and owner of the H & M Pipe Beveling Machine Company, died June 22 in Tulsa. He was well known in pipe line circles and received commendation from the Ordnance Dept., U. S. Army, during the war for pipe work done by his machines on the "Big Inch" and "Little Inch" pipe lines.

•

H. O. K. Meister, 62, general manager of the Hyatt Bearings division of General Motors Corporation, died on June 10 on Shelter Island, N. Y. Meister joined Hyatt in 1914.

•

Joseph S. Sidwell, 80, who retired as a superintendent of Sinclair Oil and Gas Company in 1945, died June 20 in Tulsa.

Companies in the News

SUNRAY OIL CORPORATION and Barnsdall Oil Company received stockholders' approval of their merger and began to operate under the Sunray emblem.

The new board of directors and its officers are **F. B. Parriott,** director and chairman of the board; **C. H. Wright,** director and president; **Edward Howell,** director, vice president, and general counsel; **Paul E. Taliaferro,** director, vice president, and assistant to the president; **D. R. Snow,** director, vice president-exploration and production; **F. L. Martin,** director, vice president-refining and sales; **W. C. Whaley,** director, vice president-California division; **W. D. Forster,** director and secretary; **J. K. Ellis,** director; **Glenn J. Smith,** director; **Alfred L. Rose,** director; **A. A. Seeligson,** director; **D. L. Frawley,** director; **Don O. Chapell,** vice president-manager, exploration; **H. O. Harder,** vice president-manager, production; **L. W. Bennett,** traesurer; **Ben L. Young,** assistant treasurer. Snow, Whaley and Frawley were formerly directors and officers of the Barnsdall Oil Company.

Organized in 1920, Sunray's original force of 30 employes has grown to more than 2000, and more than 50,000 stockholders have an interest in the company. As a result of the Sunray-Barnsdall merger, Sunray will have a crude oil production of more than 60,000 barrels per day from 3800 oil and gas wells, and becomes one of the largest independents in the producing and refining divisions of the oil industry, with assets of more than $260 million.

•

MAGNOLIA PETROLEUM COMPANY has made substantial improvements in its Employe Benefit Program, it was announced by **J. L. Latimer,** president, in a personal letter to each employe. The changes are generally to be effective September 1 for employes not in collective bargaining units, and are being offered to representatives of such units.

A feature of the new plan is the establishment of a minimum income for employes who retire from active service with certain qualifications.

•

STANDARD OIL COMPANY (INDIANA) has instituted a new service award plan for employes. Service pins reproducing the Standard Oil (Indiana) emblem will be given in recognition of 30, 20, and 10 years' service, and an engraved gold watch will be presented on retirement to employes with 30 years' service.

•

SHELL OIL COMPANY and Shell Development Company research scientists, technical representatives and executives met in California for their 37th semi-annual research conference. Approximately 120 staff members were present.

Attending from Shell Development Company, Emeryville, were **M. E. Spaght,** president; **A. J. Johnson,** vice president; and **T. W. Evans,** director of research. From New York were **A. E. Lacomble, F. S. Clulow** and **J. H. Doolittle.**

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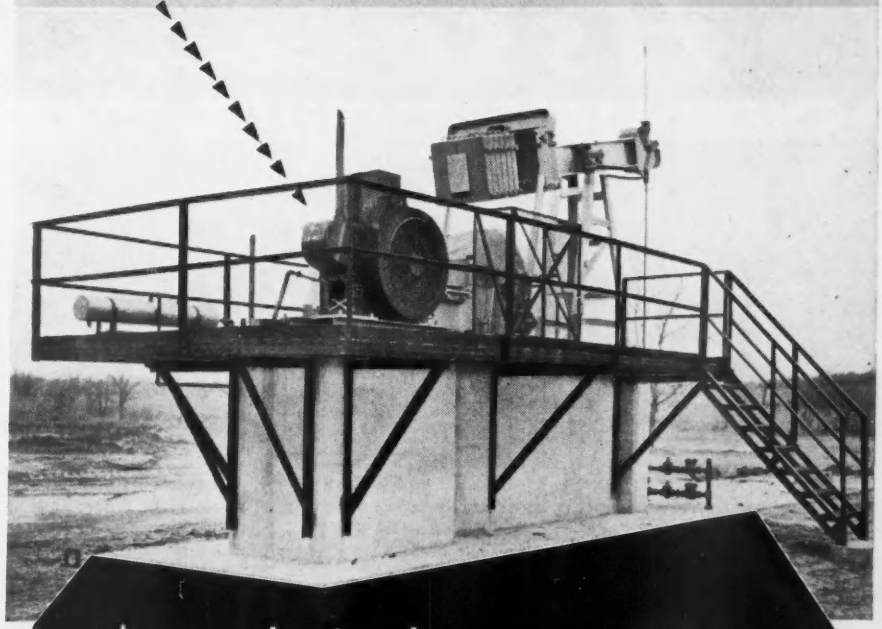

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FOR more than 3 years of continuous-duty service, this Le Roi A-288 required little more than routine inspection every other week. Oil is changed every 2000 hours. And because of the patented, closed "vaporizing-condensing" cooling system, make-up water is negligible. Furthermore, inspection requires only a few minutes time because of visible oil and water gauges — *shut down is unnecessary.*

Such performance is typical. So get after your pumping costs with Le Roi A-288's. Horsepowers range from 13 to 26, and speeds from 360 to 720 rpm. Have your Le Roi distributor show you how you can save money. Write for detailed information.

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Oklahoma
Le Roi Company Branch — Tulsa
Carson Machine & Supply Co. — Oklahoma City

East & South Texas, Gulf Coast
Southern Engine and Pump Company — Houston, Kilgore, Edinburg, Dallas, San Antonio, Corpus Christi, Texas, and Lafayette, Hauma, Louisiana.

North & West Texas, New Mexico
General Machine & Supply Co. — Odessa, Snyder, Texas.
Nortex Engine & Equipment Co.—Wichita Falls, Texas.

Kansas
Carson Machine and Supply Co.—Great Bend

Illinois — Western Kentucky
Western Machinery & Engine Company—Centralia, Illinois and St. Louis, Missouri.

Michigan
Hafer Engine Service — Reed City

Rocky Mountain Area
Gehring Equipment Co. — Casper, Wyoming, Rangeley, Colorado.

Northern Louisiana & Mississippi
Ingersoll Corporation — Shreveport, Louisiana, and Jackson, Mississippi.

West Coast
Le Roi-Rix Machinery Co. — Los Angeles, Long Beach and Bakersfield, Calif.

Appalachian Area
P. C. McKenzie Co., Pittsburgh

Canada
Lucey Export Ltd. — Calgary, Edmonton, Alberta.

Complete Sales and Service Facilities

Associations

Domestic and Foreign Visitors at a recent meeting of the Houston Chapter of Nomads are, left to right, front row, Roberto Abila, Socony-Vacuum Oil Company, Bogota, Colombia; H. E. McAfee, Colombian Petroleum Company; W. H. Siems, Hughes Tool Company, New York; T. R. Bibee, Gulf Oil Corporation, Houston; Francis G. West, Asiatic Petroleum Corporation, Houston; W. H. Larkin, Larkin Packer Company, St. Louis. Second row: Walter Ervin, Petroleos Mexicanos, Mexico; P. N. Linton, BPM, The Hague; R. S. Peterson and K. E. Waggener, Shaffer Tool Works, California; Alexander Goldie, S.O.L., State of Brunin, Borneo.

Equipment Suppliers Choose Officers for 1950-51 Term

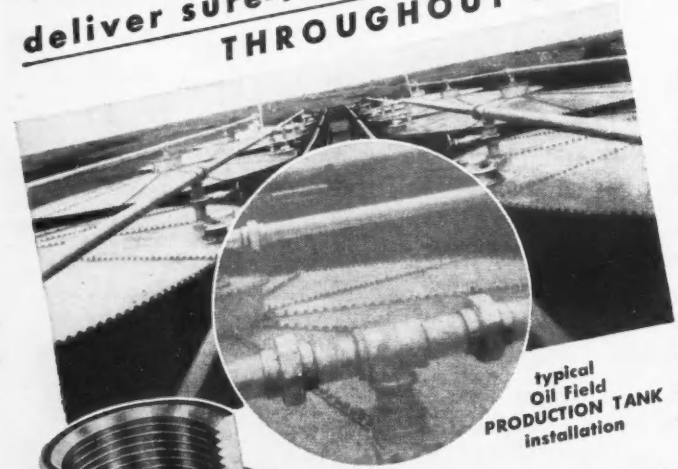
Ted Sutter, executive vice president and general manager of Baker Oil Tools, Inc., Los Angeles, was elected president of the Petroleum Equipment Suppliers Association at its 15th annual meeting in White Sulphur Springs, W. Va.

Other new officers are Fred M. Mayer, president, The Continental Supply Company, Dallas, vice president; Wharton Weems, re-elected treasurer; and H. R. Safford, Jr., re-elected executive secretary.

The firm of Vinson, Elkins & Weems, Houston, was re-elected general counsel.

CATAWISSA PERFECT SEAL UNIONS

deliver sure-fire piping dependability THROUGHOUT THE OIL FIELDS!



In high or low pressure, extremely high temperature or corrosive piping conditions, CATAWISSA HOT FORGED STEEL UNIONS are maintaining their long-standing reputation for sure-fire piping dependability!

CATAWISSA PERFECT SEAL UNIONS are designed and produced for dependable, long-life service under the severest piping conditions—made with hand ground seats that require no packing and feature Catawissa's Ball-To-Angle seat design which gives a PERFECT SEAL even when the pipe is not in alignment!

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California Oil Conservation Committee Officers Elected

The Conservation Committee of California Oil Producers has elected Bruce H. Robinson, General Petroleum Corporation, chairman. Other officers are Chester F. Dolley, Atlantic Oil Company, first vice chairman; D. L. Caldwell, Barnsdall Oil Company, second vice chairman; and J. L. Stephens, Chanslor-Canfield Midway Oil Company, secretary.

The Committee is comprised of the chairmen and vice chairmen of the state's oil producing districts. District committee members are elected by vote of the oil producers to represent various fields and districts.

Engineers' Council Accredits Kansas Petroleum Department

The Department of Petroleum Engineering in the School of Engineering and Architecture at the University of Kansas, Lawrence, Kansas, has been accredited by the Engineer's Council for Professional Development, making it the 15th so accredited in the U. S.

The following promotions were announced: Dr. Charles F. Weinaug, chairman of the Department of Petroleum Engineering, from associate professor to professor; Dr. E. L. Anders, Jr., from assistant professor of petroleum engineering to associate professor.

Utility Buyers Name Stephens

Robert V. Stephens, purchasing agent, Public Service Company of Oklahoma, Tulsa, has been named chairman of the Public Utility Buyers group of the National Purchasing Agents Association.

Well Spacing is Topic of IOCC Meeting Discussion

Members of the Interstate Oil Compact Commission at their Summer meeting at the French Lick Springs Hotel, French Lick, Ind., August 3-5, are to be guests of the states of Indiana and Kentucky. Governor Henry F. Schricker of Indiana and Governor Earle C. Clements of Kentucky will welcome members of the Commission and the oil and gas situation in both states will be discussed.

The Research and Coordinating Committee which heard Dr. H. H. Kaveler, Phillips Petroleum Company, Bartlesville, Okla., discuss well spacing problems at the Spring meeting in Biloxi, Miss., will hear C. W. Tomlinson, Ardmore, Okla., independent geologist and past president of the American Association of Petroleum Geologists, discuss the same subject, thus enabling the committee to prepare a comprehensive report on well spacing problems and factors to be taken into consideration.

The Regulatory Practices Committee has invited Elvis Utz, gas engineer for the New Mexico Oil Conservation Commission, Dan Dunnett, assistant director of conservation, Oklahoma Corporation Commission, C. H. Hinton, superintendent of operations, Panhandle Eastern Pipe Line Company, and C. W. Binkley, Phillips Petroleum Company, to discuss gas well testing, conclusions to be included in a Committee report on the subject. Dr. Paul D. Torrey, Houston, will speak on "Secondary Recovery."

Los Angeles Oil Accountants Elect H. C. Osborn President

The Petroleum Accountants Society of Los Angeles has elected Harold D. Osborn, assistant controller, General Petroleum Corporation, as president of the Society.

Harold D. Osborn

Osborn has been employed by General Petroleum Corporation 27 years, attaining his present position with the corporation in 1943.

Other officers are, first vice president, F. S. R. Sedding, Doheny-Battson Interests; second vice president, J. R. Brown, Standard Oil Company of California; secretary-treasurer, C. F. Wilmsmeier, Western Gulf Oil Company. A new director, V. T. Gilchrist, The Superior Oil Company, was elected to fill a vacancy.

Nomenclature Group Elects

E. B. Roudebush, chief scout for Gulf Oil Corporation, Tulsa, has been elected chairman of the Oklahoma Nomenclature Committee, Mid-Continent Oil and Gas Association. C. W. Michaels, chief scout, Shell Oil Company, Tulsa, is vice chairman, and E. L. Thomas, Association staff assistant, secretary. Roudebush succeeds Sam Baird, chief scout, Mid-Continent Petroleum Corporation, Tulsa.

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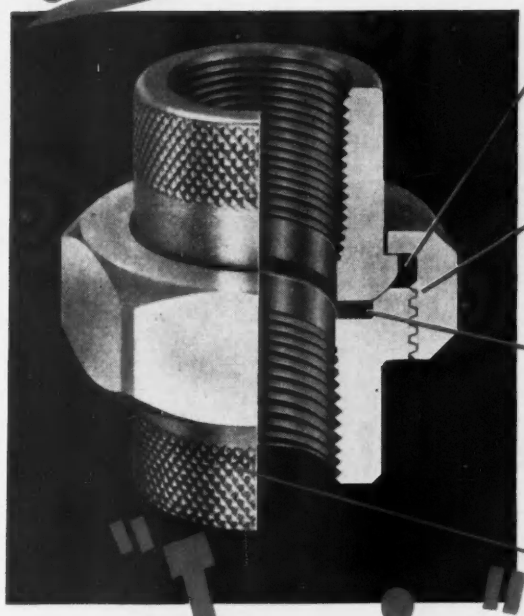
Over and Over Again!



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This is the same leak-proof sealing arrangement that has made WECO UNIONS leaders in the Oil Industry for 15 years

ACME THREADS . . . FASTER MAKE-UP
Fewer turns are required for seating contact of subs which draw up tighter with less pull on the wrench

RESILIENT, REPLACEABLE GASKET
Acting as supplementary seal, it protects metal-to-metal seat against abrasion and corrosion from line fluids and gases

KNURLED SUB ENDS
An exclusive feature minimizes wrench slippage, means easier, faster starting on pipe ends

"Junior"
WECO
Fig. 342

EVEN after repeated make-up and break-out, WECO "Junior" all steel unions continue to give perfect service. The metal-to-metal ball and cone seat, meeting in a concentric circle is self-aligning and perfect seating for a leak-proof seal. The heavier wall construction of sub ends . . . the rugged nut with heavy acme threads gives them greater strength and longer life.

These 3000 lb. non-shock C.W.P. Unions are available ⅛" through 2"; machine finish or Wecolyte cadmium plated.

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ASK FOR WECO "JUNIOR" UNIONS AT YOUR INDUSTRIAL, MILL SUPPLY, OR OIL FIELD SUPPLY STORE.

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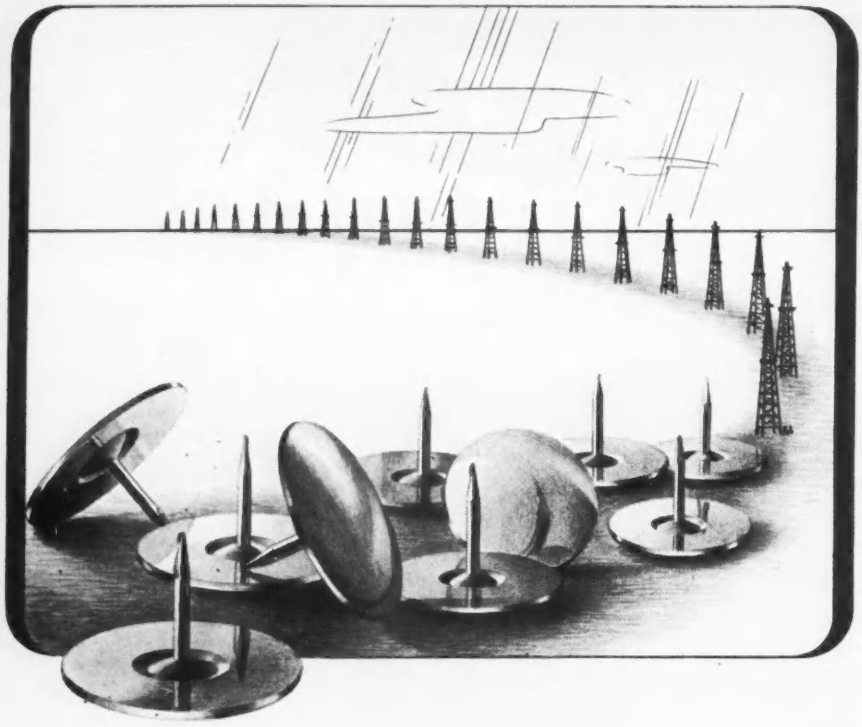

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ASSOCIATIONS

Lane-Wells Man Elected To NIAA National Office

Edward E. Beauchamp, Lane-Wells Company's advertising engineer, has been elected a national vice president of National Industrial Advertisers' Association. He is one of the few West Coast men ever elected to national office in the NIAA.

Other officers are Bennett S. Chapple, U. S. Steel Corporation, president; Charles W. Shugert, Shell Oil Company, New York, secretary-treasurer; H. James Christy, Rochester, N. Y., James Totten, Toronto, Canada, and Robert A. Joyce, Youngstown, Ohio, vice presidents.

Penn Grade Crude Association Re-Elects Streeter President

C. E. Streeter, Bradford, Penn., oil producer, was re-elected president of the Pennsylvania Grade Crude Oil Association.

The board of directors elected James A. Upham of Mt. Vernon, Ohio, an independent oil producer and president of the Ohio Oil and Gas Association, a director.

Case Institute Schedules Corrosion Short Course

Nine 2½-hour lecture periods are scheduled for the Case Institute of Technology corrosion short course to be held September 25-29 at Cleveland. Dr. R. B. Hoxeng of the Institute is in charge of the short course, which is being conducted with the cooperation of NACE.

Socony-Vacuum Production Awards Seven Scholarships

Awarding of scholarships to 7 universities and selection of 4 employes to receive fellowships during the 1950-51 academic year was announced by the Producing department of the Socony-Vacuum Oil Company, Inc.

These educational opportunities are part of a scholarship-fellowship program which was initiated by Socony-Vacuum's Producing department in 1949 as a $200,000 project over a four-year period.

In this program the overseas operating companies throughout the world and the affiliated companies in the U. S., the Magnolia Petroleum Company, Dallas, and the General Petroleum Corporation, Los Angeles, are participating.

Mexican Geologists Organize

Mexican geologists have organized the Asociacion Mexicana de Geologos Petroleos with Manuel Rodriguez Aguilar, chief of the department of exploration, Petroleos Mexicanos, president; Alfonso Barnetche, manager of production, PEMEX, vice president; Guillermo Salas, consulting geologist, secretary-treasurer; Manuel Alvarez, Jr., exploration department, Pemex, editor.

Conference Coordinator Named

Paul J. Hubbell has been appointed coordinator of the Industrial Management Conference program, Division of Engineering and Industrial Extension, Oklahoma A. and M. College, Stillwater.

EQUIPMENT AND SERVICE SUPPLIERS' NOTES

Hughes Tool Company Will Build $2 Million Laboratory in Houston

Hughes Tool Company has announced plans for the erection of new $2 million engineering laboratories in Houston. The building, which will cover 75,000 square feet of floor space, will have a two-story center structure containing the metallographic laboratory, chemical laboratory, emission spectrum laboratory, projection room, library, and offices. Wings to the east, north, and west will house the welding laboratory, laboratory machine shop, and mechanical testing station.

The entire building, scheduled for June, 1951, completion, will be air-conditioned, including the working floor of the field size drilling rig in the mechanical testing section. New equipment, to cost $½ million, will be added to that moved from the present labs.

In the proposed laboratories new designs and improvements on present products will be developed and standardized, and continuous research will be carried out in search of better materials and advanced designs for oil industry products.

Architect's drawing of the proposed $2 million Hughes Tool Company engineering laboratories to be constructed in Houston.

A. O. Smith Announces Plans for Expanding Facilities in the East

A. O. Smith Corporation plans expansion of its electric motor manufacturing facilities at Tipp City, Ohio, where it recently bought Whirl-A-Way Motors, Inc. A 60,000-square-foot factory, costing approximately $500,000 to build and equip, is to be completed by early fall. The line of fractional horsepower motors will be expanded to include polyphase motors. The Tipp City operation now becomes the eastern motor division of A. O. Smith with D. L. Mills, former president of Whirl-A-Way, as manager. Eastern sales and administrative offices will be located at Dayton.

New Oil Report Covering Mid-West Published Bi-Weekly by Virgil Kays

A new oil report covering all active operations in Illinois, Indiana, and Kentucky, and carrying items of new discoveries in adjoining states will be published twice weekly by Virgil W. Kays, Evansville, Ind. Kays will also supply completion cards for filing, and township maps.

Kays had been editor of the Tri-State Oil Report for the past 4 years.

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LINE PIPE COUPLINGS A.P.I.
⅛" to 12"—Seamless and Special Processed—Black or Galvanized

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Denver—Earl H. Jones & Co., 1863 Wazee St
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Erie, Pa.—R. J. Maggi, Box 711
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WHEELING MACHINE PRODUCTS COMPANY
ELM GROVE STATION — WHEELING, W. VA.

An Outdoor Party given by Dozier Graham Eastman to celebrate its 25th year in business was attended by more than 300 clients, media representatives, suppliers, and friends. Shown here are, left to right, Tom Boyd, Baash-Ross Tool Company; Tom Bell, The Texas Company; and H. Wotkyns, Baash-Ross Tool Company.

Manhart, Millison, and Beebe Form Exploration Consulting Partnership

T. A. Manhart, Clark Millison, and B. W. Beebe have formed an exploration consulting partnership, Manhart, Millison & Beebe, in Tulsa. The firm will perform all types of geological and geophysical services in domestic and foreign areas.

T. A. Manhart

Clark Millison

B. W. Beebe

Manhart, a graduate of the Colorado School of Mines, joined Seismograph Service Corporation as party chief in 1933, and through successive promotions became executive vice president. In 1949 he organized Petroleum Consultants, Inc., of which he is president. He was national secretary and treasurer of SEG in 1947-1948.

Millison was graduated from Columbia University and Oklahoma University, and joined Shell Oil Company as a geologist in 1927. In 1936 he resigned as regional geologist for the Southern Mid-Continent area to become a consulting geologist.

Beebe, a graduate of the University of Wichita and California Institute of Technology, started work with Shell as a geologist in 1934, and later became assistant to the vice president in charge of exploration. In 1938 he joined British-American Oil Producing Company, in 1942 organized the Exploration department for the Bay Petroleum Company in Denver as chief geologist and vice president, and in 1947 became exploration manager for Anderson-Prichard Oil Corporation.

Three Baroid Sales Division Men Advanced by National Lead Company

Reginald Rowand, who has been superintendent of Baroid Sales division's Magnet Cove, Ark., barytes mines and plant, since 1949, has been appointed manager of the company's Production department. Rowland joined Baroid in 1945 as superintendent of construction and maintenance, and in 1946 he was made superintendent of bentonite plants and properties with headquarters at Belle Fourche, S. D.

Earl H. Murchison, former superintendent of the El Portal, Calif., barytes mines and plant, replaces Rowand at Magnet Cove. Murchison became connected with the Cartersville, Ga., plant in 1919 before it was a part of Baroid. In 1924 he was made superintendent of the Fountain Farm, Mo., plant, leaving in 1928 to go to El Portal.

Robert B. Spitzer, general superintendent of the Rossi-Merced mines and plant, takes on the additional duties of superintendent at El Portal.

C. J. Woodard Given Promotion By Pelton Water Wheel Company

C. J. Woodard, formerly in charge of sales and service of the Long Stroke Hydraulic Pumping Jack division, Pelton Water Wheel Company, has been made manager of the Oil Industry Machinery division with headquarters at Los Angeles.

C. J. Woodard

Woodard attended Stanford University and the California Institute of Technology, and served as engineering officer aboard a destroyer during the war. He joined Pelton as an engineer in the Hydraulic Turbine and Valve division and was later assigned to the development and marketing of long stroke hydraulic pumping equipment.

Oil Well Supply Appointments Include Imperial Works Manager

Thomas E. Regan has been named works manager of the Imperial Works of Oil Well Supply Company, Oil City, Penn., succeeding H. W. Cloud, resigned. Regan had been manager of the Wilson-Snyder plant at Braddock, Penn.

W. D. Bauman, formerly division credit manager for the Eastern division, has been named assistant to the treasurer, at the company's Dallas home office. He is succeeded by John C. Donahue, credit and collections supervisor in the Eastern division headquarters at Columbus, Ohio.

R-M Moves New York Offices and Marketing Merchandising Department

The New York City offices of Raybestos-Manhattan, Inc., have been moved to 500 Fifth Avenue. These offices include the New York and New England district office of the Manhattan Rubber division and the Corporation Export department.

The Department of Marketing and Merchandising has been moved to the corporation's headquarters at Passaic, N. J.

Dresser's San Francisco Warehouse Will Serve West Coast Districts

Dresser Manufacturing division, Dresser Industries, Inc., has opened a new West Coast warehouse in San Francisco. A complete line of stocks, selected according to the needs of the western states, is carried. The new warehouse will give improved delivery and sales service to Dresser's Western district, now under the supervision of R. J. Driggs, district manager. Paul McCullough, with the company 25 years, is warehouse manager.

R. J. Driggs

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TRADING POST

CLASSIFIED ADS SECTION

Golden Anniversary Is Observed By Acme Fishing Tool Company

In celebrating its 50th Anniversary this year, Acme Fishing Tool Company, Parkersburg, W. Va., takes pardonable pride in the place it has established for itself among corporate free enterprise.

The story first finds George L. McKain, after youthful years as an oil country employe, "going on his own" in 1895 as a drilling contractor at Smithfield, W. Va. Soon he was operating 18 strings of cable tools. With his nearest supply base 25 miles away, at Mannington, W. Va., delays were costly, particularly on the frequent fishing jobs. In 1896 he decided to put in his own shop to design and make his own tools. In 1899 he disposed of his contracting business to devote full time to his shop and fishing tool business. Moving his shop to Salem, W. Va., in 1900, McKain began the manufacture of fishing tools. These tools were not offered for outright sale, but on a 3-day minimum rental basis, with or without a capable fisherman.

Lewis M. Ludlow

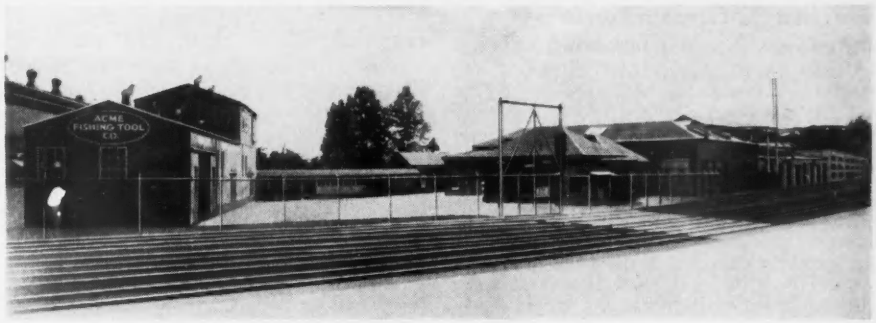
George L. McKain

Karl L. Elliott

Walter P. McKain

Three years later, the one-man controlled business was moved to Parkersburg and incorporated as a West Virginia corporation. By 1914 warehouse and office branches were established in West Virginia, Ohio, Kentucky, Illinois and Oklahoma. New fishing tools were designed to keep pace with requirements in the new fields. World War I found Acme busy operating 6 forging hammers, producing specification forgings essential to the war effort. Although not slighting the cable tool market, never again—since the 1914-16 slump—has Acme "put all its eggs in the one basket."

McKain was drowned on July 28, 1918, while trying to rescue one of his shop employes during a company outing. Lewis M. Ludlow, a son-in-law of McKain, became Acme's president and general manager and for 32 years has filled the duo-position. Next in official status, and for 30 years President Ludlow's constant management associate, is Karl L. Elliott. In addition to his duties as treasurer and general sales manager, Elliott is president of Pattin Manufacturing Company, Acme's affiliate at Marietta, Ohio. One key position, that of plant superintendent, is held by A. D. (Mac) McTaggart, whose 36 years' continuous service dates his tutelage as a master toolmaker from the days of Founder McKain. Walter P. McKain, son of Founder George L., now is chief engineer.



Acme Fishing Tool Company's Parkersburg, W. Va., plant as it appears today.

In 1920 it was decided to sell—not just rent—fishing tools, and to manufacture and market cable tools. As part of this expansion program, Donovan Boiler Works plant was purchased. In 1942, Pattin Bros. Company, since 1888 manufacturers exclusively of oil country equipment, was acquired by outright purchase.

Not until 1921 did export business get Acme's active attention. Since then, this department—operating as Acme Well Supply Company—has accounted for a substantial sales volume.

In 1922 all company branches were closed out and tool stocks were placed with selected distributors. Today, there are 508 Acme distributors in all active oil states. Acme now manufactures nearly 200 fishing tools and engages in fishing service, water well cable tools, forge and machine shop service for industry, export, oil field engines, powers and repair parts, and electric welded steel storage tanks for oil and water.

Former Petroleum Writer Joins Geological and Engineering Firm

Charles J. Deegan has resigned as associate editor of *The Oil and Gas Journal* and has joined the firm of Cummins, Berger & Pishny, consulting geologists and engineers, Fort Worth.

Charles J. Deegan

For the past six years, Deegan has been in charge of exploration and economics for the Journal. During the war he spent 2½ years in Washington with the PAW, and before that had worked as geologist, engineer and economist for Continental Oil Company and Cities Service Oil Company.

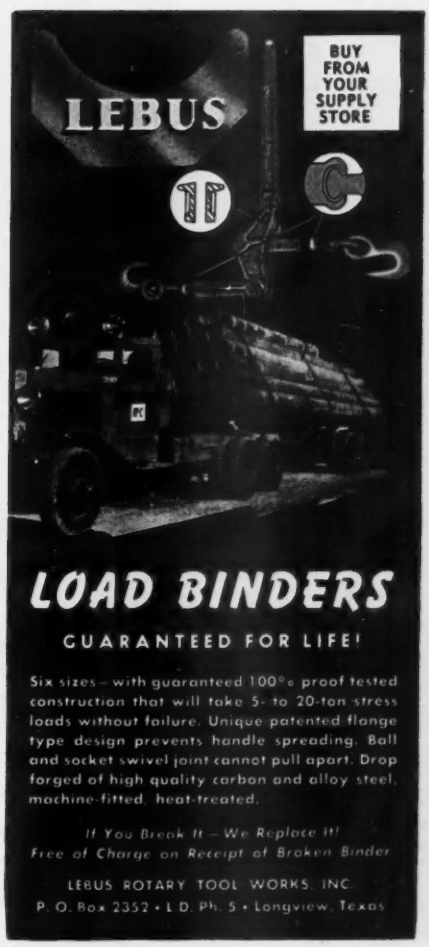
Geophysicist Establishes Office

M. P. Jones has resigned as president of Geotechnical Exploration Corporation to establish an office as consultant at 3552 Rankin, Dallas. He is engaged in various phases of geophysical exploration and research, specializing in review interpretation of seismic data and consultation and supervision of exploration programs.

Cooper-Bessemer and British Firm Contract to Build Compressors

The Cooper-Bessemer Corporation and Harland and Wolff, Ltd., British shipbuilder and engine manufacturer, have entered an agreement which licenses Harland and Wolff to build Cooper-Bessemer "V" angle-type compressors abroad. The compressors covered by the contract are the type JM motor-driven units, and the GMX, GMV and GMW "V" angle-type gas engine-driven units.

Harland and Wolff will manufacture and sell the compressor line to many of the countries in the sterling area.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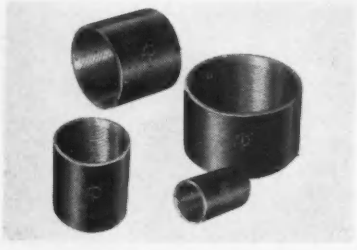
California Oil Concern Purchases United Geophysical Company Stock

Union Oil Company of California has purchased from Herbert Hoover, Jr., and his associates, all stock in United Geophysical Company, Inc., and United Geophysical Company, S. A. Union Oil Company stated that, as a result of the acquisition, it will be able to work out a closer and more effective cooperation between its geological department and the geophysical crews used in its own work. United Geophysical, it was stated, will be able to increase its operations particularly in the development of new methods and techniques of prospecting.

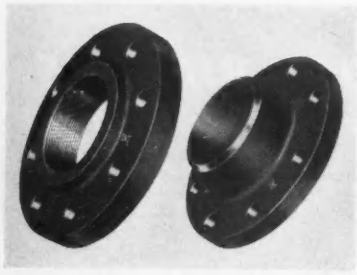
There will be no change in the management of United Geophysical as a result of the sale. Hoover will remain as president and active manager and United Geophysical will continue to do contract work. United Geophysical will continue to maintain its offices in Pasadena, Calif.

Cleco Opens Factory in Detroit

The Cleco division of the Reed Roller Bit Company has announced the opening of a new factory branch and warehouse at 2832 East Grand Boulevard, Detroit. Jim Reed and Roger Winship have been appointed factory representatives for the Detroit area, with headquarters at the new address.



is a shorter distance, more economically covered, when your Couplings and Flanges perform right!



No question about it, **reliable** Couplings and Flanges play a big part in delivering a better product to the ultimate consumer.

Harrisburg Couplings (made to A.P.I. specifications) and Harrisburg Flanges (manufactured to A.S.A. standards) have an enviable reputation for **reliability.** They perform right because they are made right.

Ninety-seven years of manufacturing experience and keeping promises is behind those statements!

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STEEL CORPORATION
Harrisburg 8, Pennsylvania

Custom-Built Quality Products in Quantity
97 YEARS IN PENNSYLVANIA'S CAPITAL

McClendon as New President Heads Halliburton's List of Promotions

Wallace R. (Mac) McClendon, vice president in charge of field operations since 1942, has been appointed president of Halliburton Oil Well Cementing Company. He replaces John C. Halliburton who is retiring.

W. R. McClendon

McClendon has been with Halliburton since its incorporation, heading Gulf Coast operations at Houston until 1942 when he was moved to the Duncan home office as vice president.

Other Halliburton announcements include the election of L. D. Campbell, vice president and secretary treasurer, to the board of directors. L. B. Meaders succeeds McClendon as vice president in charge of field operations. Ralph R. Emery was elected vice president in charge of foreign operations. Wilfred Tapper became vice president of electrical well services. W. D. Owsley was named vice president and technical adviser to executive officers. Grover Kilgore was appointed vice president in charge of sales and advertising. R. G. Kelly replaced Meaders as regional manager of the West Texas-New Mexico division.

R. G. Kelly, Halliburton Oil Well Cementing Company's West Texas-New Mexico division superintendent at Midland, has been named Central region manager and transferred to Halliburton's home office at Duncan, Okla. The new regional manager will supervise Halliburton's California, West Texas-New Mexico, Central Texas, East Texas, and North Louisiana divisions.

Succeeding Kelly as West Texas-New Mexico division superintendent at Midland is P. C. (Bill) Mayfield, former assistant superintendent. New assistant superintendents at Midland are Leroy Muse and B. H. (Joe) Clark.

Kelly was promoted to Halliburton's Central region managership to fill the post vacated by Meaders.

The new regional manager was employed by Halliburton in May, 1930, at Odessa, Texas. Assignments followed at Hobbs, N. M.; Midland; and Shreveport, where he became superintendent of the North Louisiana division. He returned to Midland in November, 1947, as West Texas-New Mexico division superintendent.

Mayfield began with Halliburton at Kermit, Texas; was promoted to fieldman at Big Lake, Texas; and came to Midland in August, 1947, as assistant superintendent. Muse began with Halliburton at Kermit and for the past 7 years has been West Texas-New Mexico division testing fieldman, stationed at Odessa. Clark started his Halliburton career at Olney, Texas, in September, 1934; was promoted to fieldman at Seagraves, Texas, in January, 1939, and came to Odessa in December, 1944.

Sperry-Sun Well Surveying Company's annual sales conference in Houston brought together sales and service engineers from points throughout the nation to review new and improved developments and make plans for the coming year. Shown are front row Beverly Morgan, Ross R. Blakely, John B. Peddy, Bert A. Cabaniss, Harry M. Lowe, W. F. (Bill) Krueger. Second row, Quentin B. Marsh, A. J. (Jack) Goolsbee, R. E. (Bob) Keyes, J. V. (Johnny) Evans, R. L. Perkins. Back row, A. B. Palmer, S. H. Williston.

Two Appointments Announced by Rockwell Manufacturing Company

L. A. Dixon, Jr., has been appointed assistant vice president of the Meter and Valve division of Rockwell Manufacturing Company. He will assist in the coordination of sales and factory problems, and will headquarter in Pittsburgh.

Dixon has been associated with the meter industry since his graduation from Pennsylvania State College. Shortly after the war he made a detailed report to the U. S. Department of Commerce on foreign gas meter methods and designs. Dixon started in the Engineering department of the Pittsburgh-Du Bois Company and was made executive vice president in 1944. When Rockwell acquired that company in October, 1947, he became assistant manager.

The company has named Clarence E. Muehlberg sales manager of gas products. A graduate in mechanical engineering of the Missouri School of Mines, Muehlberg has been affiliated with the gas utility field for 30 years.

Eastman Promotes David P. Neill

David P. Neill, former district sales manager for Eastman Oil Well Survey Company in West Texas, has been made general sales manager for the new Eastman International Company with headquarters at Denver.

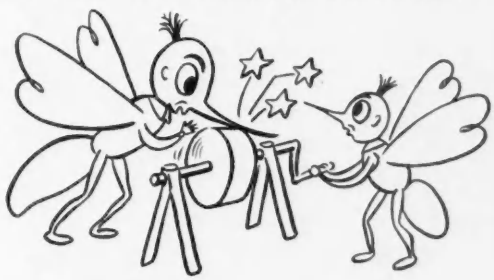
Stephenson Appointed Assistant Chief Engineer by Merla Tool

A. D. Stephenson, Jr.

A. D. Stephenson, Jr., has been appointed as assistant chief engineer of Merla Tool Corporation.

A recent graduate of Southern Methodist University, Stephenson will devote most of his time to experimental design and the development of modern techniques of gas lift production.

FOR DEEP OR SHALLOW DRILLING . . .



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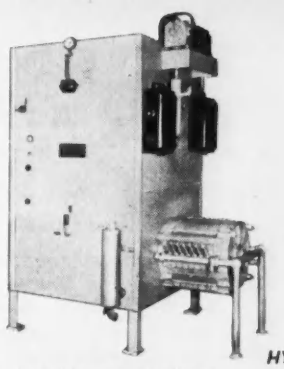

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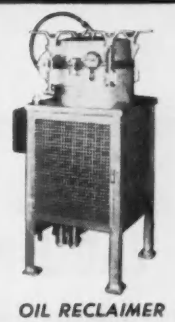

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English Firm Is Organized to Make Jerguson Gage and Valve Products

Jerguson Gage and Valve Company, in collaboration with Tress Engineering Company, has organized an English company, Jerguson Tress Gage & Valve Company, Ltd., for manufacture and distribution of Jerguson products. The English firm has headquarters at Africa House, London, and uses the manufacturing facilities of Tress Engineering Company, near Newcastle on Tyne.

Officers and directors of the new company are Cecil W. B. Tress, chairman; E. Sheard, chief engineer, and W. Birks Creasser, sales manager, with headquarters in London; and Brooks Stevens, Jr., E. E. van Ham, N. Garfield, and James A. Ford, with headquarters at Somerville, Mass.

Aero Service and Spartan Organize Canadian Technical Air Enterprise

Aero Service Corporation, Philadelphia, and Spartan Air Service, Ltd., Ottawa, Ontario, have organized Canadian Aero Service, Ltd., an affiliate of both companies. The new firm will engage in aerial topographic mapping and airborne magnetometer surveys throughout Canada.

President is Thomas M. O'Malley. James Wells is vice president, and John Johnson, secretary-treasurer.

Jerry Ormand

R. D. Fagan

ICI Service Opens New Division in West Texas With Fagan as Manager

ICI Service recently opened a new division in West Texas with headquarters at Odessa. Besides oil well cementing the company will offer Perfo-Jet (jet casing perforating) and Strata-Jet (jet formation penetrating) in West Texas fields.

R. D. (Bob) Fagan has been named division manager with Jerry Ormand as his assistant.

Oil Well Supply Company Opens New Quarters for El Dorado Store

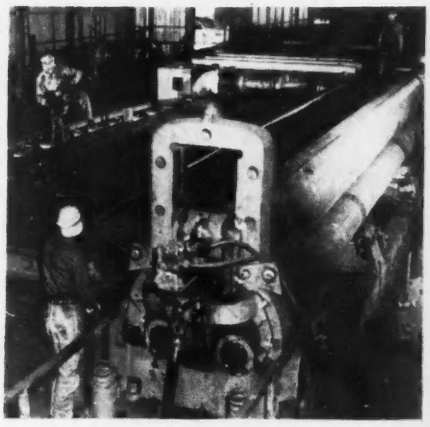
The new quarters of Oil Well Supply Company's El Dorado, Ark., store were formally presented to the public with an open house. The new building is at Washington and Hillsboro streets, site of the former building.

Manager of the store is Tommy M. Casey. Other staff members include Dan R. Fletcher, field salesman; David Bussel, production equipment salesman; and Charles Windham, in charge of the bottom hole pump shop.

Master Tank and Welding Employs Advanced Methods of Pipe Building

Master Tank and Welding, Dallas, the first pipe producing establishment to be located in the Southwest, is putting out pipe at the rate of 1¾ miles a day.

The firm now has 2 complete pipe mills. The first, completed late in 1948, produces 20- to 24-inch pipe in lengths up to 30 feet by the "press" method, and the second, built a year later, manufactures 24- to 36-inch pipe in lengths up to 31½ feet by the roll process.



Bending rolls in the new No. 2 Plant at Master Tank and Welding's Dallas pipe mill.

Eagle-Picher Lead Wool

STOPS

bottom water

Rule out the risk of oil-wasting bottom water shutdown by tamping Eagle-Picher Lead Wool in the hole. The finely stranded, flexible metallic wool makes a water-tight plug that seals every crack and crevice. Comes in convenient 50-pound sacks—easy to place in special cartridge-shaped Eagle-Picher Wire Containers sized to fit all casings. Order through your jobber.

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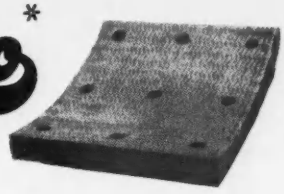
EAGLE EP PICHER

These 3 Eagle-Picher Bearing Metals meet most requirements

1. **Dreadnaught** — for extreme speed and heavy-duty conditions.
2. **Outlasta** — for medium speed and average-load conditions.
3. **Durable** — for low speed and light-duty conditions.

Standco* NO-SMOKE



BRAKE LINING

SALUTES

the new BREWSTER N-12 ROTARY DRAWWORKS

The new Brewster N-12 uses Standco Brake Blocks because they produce *even* feed-off and prolong the life of brake-rims from 20% to 50% or more. Consequently, Standco Brake Blocks cost you "less than nothing" because they save brake-rims and down-time for replacements. Use Standco to save *your* brake-rims!

"DRILLERS PREFER STANDCO"

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Factory and General Offices

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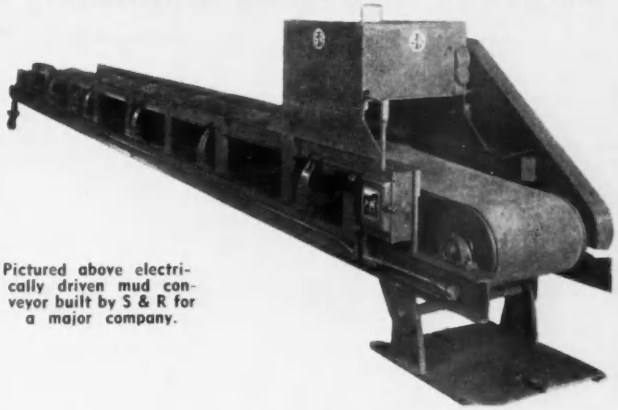
S & R SPECIAL *Custom Built*
MUD CONVEYORS FOR DRILLING BARGES



Pictured above electrically driven mud conveyor built by S & R for a major company.

Here's the answer to efficient movement of mud for your drilling barge—it's S & R's custom built, electrically powered, chain drive mud conveyor.

Built for heavy duty service with quality materials equipped with reversible belt, troughing idlers, protected easily accessible drive housing. Operates efficiently all positions to 35° off horizontal. Built in sizes to 40 feet.

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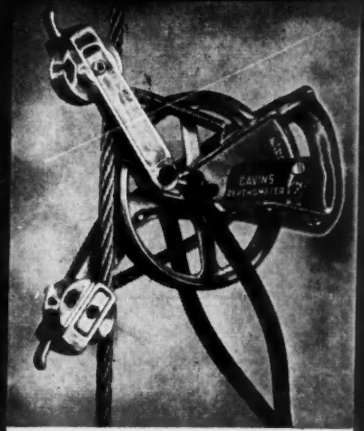
Here's the Accurate Way to take Wire Line Measurements

Easy to use

Light and handy to carry

No more "Stringing-in" Guess Work



Gives you accurate depth

Direct reading

Pays for itself in a short time

Hundreds of Cavins Depthometers are in successful service giving their owners direct-reading, accurate well measurements. This strong, simple device comes in a handy carrying case (weighs only 17 pounds)—is put on the line in a few seconds, and tells you where bottom is quickly and dependably. —Write for folder to The Cavins Co., 2853 Cherry Ave., Long Beach 6, California.

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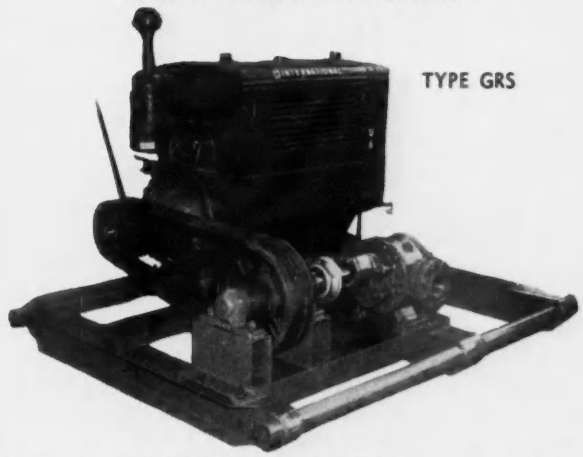
WORTHINGTON

Heavy-Duty

ROTARY PUMP

TYPE GRS



Illustrated is a Worthington 3" type GRS Rotary Pump, directly connected to an automotive-type engine—a highly efficient unit for continuous, heavy-duty service. Handles pressures up to 300 PSI, continuous.

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NEW DRILL PIPE FOR SALE

Immediate Delivery from Houston Stock at Less Than Carload Direct Mill Price

28,000 ft. 4½" OD 16.60# Grade E, Drill Pipe with 6" OD F. H. Spang Double Seal Shrink Thread Tool Jts. with Five ⅝" Hard Bands.

5,700 ft. 4½" OD 16.60# Grade E, Drill Pipe with 5¾" OD F. H. Reed Super Shrink Grip Tool Jts. with 1½" Hard Bands.

14,000 ft. 3½" OD 13.30# Grade E, Drill Pipe with 4⅝" OD F. H. Spang Double Seal Shrink Thread Tool Jts. with 1½" Hard Face.

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21,000 mineral right acres underlying 44,000 acres of land in Mississippi, Alabama, Florida and Georgia, comprising in the main a ½ interest, and, in several cases, ¾ and all rights. For sale by States or blocks but not individual tracts. For further information

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■ Drilling Rig for sale: Failing 314, mounted on GMC, 6x6; 1,000 ft. drill-pipe; light plant and all accessories. Garner Instrument Co., Stinson Field, San Antonio.

Bethlehem 8-50 Hoist with 1 WAK Waukesha Motor and Torque Converter. Excellent condition. Chet Whaley Well Servicing Company, 909-A City National Bank Building, Houston 2, Texas. FAirfax 1998.

FOR SALE

Electric drilling unit, has 12,000 feet of prestretched, preformed electrical conducting cable, breaking strength 40,000 lbs., 3 drilling tools capable of perforating casing without burring, and taking lateral formation samples in open holes, and two electrical magnetic fishing tools capable of lifting 1,000 to 1,200 lbs.

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2 New Hydraulic Shot Hole Drill Rigs at Special Price. Capacity, 400' of 3" hole with 2⅜" drill pipe comprising 1½ ton Ford truck, 25' 6" tubular mast with double acting hydraulic rams to provide 10' continuous non-chucking stroke, hydraulic operated winch, hydraulic powered rotary table, hydraulic rotary table push down, G-D 4 x 5 mud pump, swivel, 49 sections of 2⅜" drill pipe 10' long and complete accessory equipment. Write or call C. R. Athy, c/o International Derrick & Equipment Co., Atlantic Bldg., Dallas, telephone R-1031.

■ Well drills, spudders, rotaries, core-drills. All sizes new and used equipment. Tools, drill pipe, cable, pipe. Fishing tools rented. Everything for well drilling. Pressey & Son, Pueblo, Colorado.

■ Completely rebuilt and guaranteed for 60 days, Climax Model R41 gasoline power unit with clutch. 89 net horsepower at 1200 RPM, 72 at 900 RPM continuous. Used less than a year. $1500.00. Wm. F. Surgi Equipment Corporation, P. O. Box 1309, New Orleans, Louisiana.

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■ CUBA, MOST PROMISING OIL LANDS. Large areas, Good geology. Reasonable royalty, rental or outright sales. No production curtailment. Ready high price market, unlimited demand. Refinery available. Holdings in Pinar del Rio, Havana, Matanzas and Sta. Clara Provinces on most favorable oil structures known. Maps and information available. Cuban Oil Enterprises. Aguiar 574 St. Havana, Cuba.

New Books,

State Statistics

A comprehensive statistical and reference book on the domestic oil and gas industry, entitled "The Oil Producing Industry in Your State," contains complete statistical information on all phases of the oil industry in 26 producing states, as well as charts and graphs which deal with national economic trends in the industry.

Significant comparisons shown in charts include production and reserve increases over a 35-year period, oil production as compared with other minerals, value of production in relation to other oil industry trends, price index over a 25-year period, and a comparison of hourly earnings in petroleum and other industries.

In statistical summaries on each state the book contains information on the geographical extent and economic contributions of the industry from the year of first recorded production up to January 1, 1950.

It also shows leasing and exploration figures in 6 non-producing states in which much interest has beeen shown by the industry. In North Dakota, for example, 18 percent of the total land area of the state has been leased for exploratory purposes.

J. E. Warren, Midland, Texas, president of IPAA, is author of a foreword which points up the expansion of the oil and gas industry in recent years and its importance as the nation's number one mineral industry.

Independent Petroleum Association of America, Information Service, P. O. Box 1019, Tulsa.

SITUATIONS WANTED

Airline transport pilot, aircraft and engine mechanic, flight instructor, instrument. Age 26, 2 years' college engineering. 2200 hours, 900 twin. Beech airline and executive transport. Desire position with progressive company with lots of potential use for air transportation. Box 84-W, World Oil, Houston, Texas.

■ Geologist, 27, single, good personal habits, 3 years' experience major company, desires geological, scouting, or land work with independent. Address Box 85-W, World Oil, Houston, Texas.

SENIOR GEOLOGICAL Draftsman—experienced in well posting, datums, sections, lease posting, hand coloring of geological reports, etc. Neat freehand lettering. Age 36, married, presently employed in Los Angeles, California. Desires position in moderately sized city. Box 86-W, care World Oil, Houston, Texas.

WANTED TO BUY

Eastern manufacturer of oil well production equipment interested in warehouse in Southern Illinois. Interested in joint warehouse with associated but non-competitive company. Box 87-W, care World Oil, Houston, Texas.

■ We WILL BUY Producing Oil Royalties. Send Particulars. Standard Security Co., 115 Broadway, New York 6, New York.

Maps and Movies

Secondary Recovery

The second edition of "Secondary Recovery of Oil in the U. S.," prepared by members of the API standing subcommittee on secondary recovery methods, contains about 800 pages of text and reference tables. The book deals with the latest factual data pertaining to secondary recovery practices in all oil-producing areas of the U. S.

The new book contains some of the data included in the first edition, as printed in 1942, plus corrections and revisions of the first work, and all new material developed on secondary recovery since 1942. The publication of the second edition represents the culmination of more than 11 years of constant work by the standing subcommittee on secondary recovery methods, the members of which come from numerous oil companies and petroleum agencies throughout the country.

American Petroleum Institute, 50 West 50th Street, New York.

Safety Movies

The API Department of Safety has set up a film library to help the oil industry train its employes and keep them safety-conscious.

The library has been started with 5 16-millimeter sound-color films. Additional motion pictures may be added later, depending upon the results achieved from the present operation.

The pictures currently in the library were made originally for single company use, but have been re-edited to make them suitable for the entire industry.

Among the films available are the following:

For General Meetings:

"Minutes That Count"—Part 1, (30 minutes—$175); An instructive presentation of first aid treatment of arterial bleeding and the dressing of cuts and open wounds. The circulatory system is explained and emphasis is placed upon proper procedures to follow in rendering aid to stop or minimize loss of blood.

"Minutes That Count"—Part 2, (30 minutes—$185); This film presents artificial respiration, the handling of dislocations, fractures, infections, and transporting the wounded. By actual demonstration, it shows procedures to follow and necessary precautions in administering first aid.

For Production Safety and Training Meetings:

"Hazardous Helper"—(16 minutes—$115); A story of the danger of catheads used in drilling operations, and the precautions to be taken to make them safe. An effective presentation designed to encourage safe practices and stimulate interest in the care, maintenance, and operation of this useful yet hazardous equipment.

"More Than Magic"—(15 minutes—$120); An unusual story treatment in which a parallel is drawn between the acts of a magician and the job of handling tongs, slips and elevators on a drilling rig. Constant flashbacks to the magician provide a comparison that shows how preparedness, skill, caution, alertness and teamwork are essential to the success of any performance.

"Gee! another API streamliner!"

That's right, Chico! Santa Fe will run

4 streamlined trains

to API Los Angeles, Nov. 1950

From NEW YORK CITY . . . CHICAGO . . . TULSA and HOUSTON streamliners will run over the Santa Fe to Los Angeles for API travelers. These fine streamliners will provide the best of equipment, friendly hospitality and those wonderful Fred Harvey meals. (New York special via NYC Ry. to Chicago.)

Let one of these Santa Fe offices plan your trip. Write or phone today:

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J. S. Rollman, City Pass. Agt., Tulsa
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P. H. Swinney, Div. Pass. Agt., Houston
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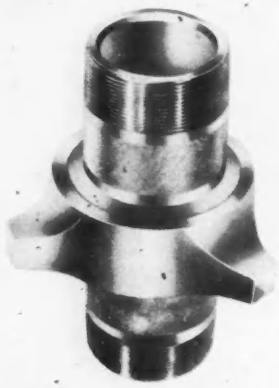
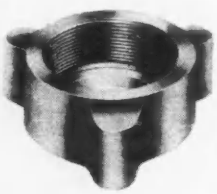
DRILLING EQUIPMENT MFG. CO.
DEMCO
OKLAHOMA CITY, OKLA. U.S.A.

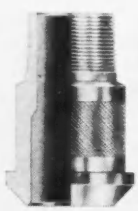
HYDRAULIC HOSE ADAPTERS



Under the most rigid tests DEMCO adapters have proved themselves most efficient, economical, foolproof and safe.
Designed to take the stress of high pressure at any depth and eliminate all possible resistance to flow. Made of high quality non-crystalizing steel. Precision machined to A.P.I. specifications and knurled for better grip. Outer surfaces electroplated to retard corrosion.

Designed for 3000 lbs. working pressure, 6000 lbs. test.

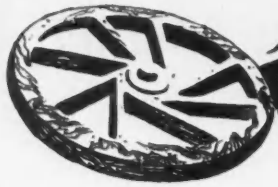




These Adapters and Couplings meet the requirements of all major swivel manufacturers, and will make up any combination or hook-up in the three or four-inch A.P.I. series for both swivel and standpipe.

Sold through your supply store.

DRILLING EQUIPMENT MFG. CO.
OKLAHOMA CITY, OKLAHOMA
PHONE 6-1342 845 S.E. 29th St. Box 4272



SQUEAKS from the BULLWHEEL

Economy Brand

During the big drouth that gripped the Western states a few years back two cattlemen were discussing their plight.

"Things are sure tough out my way," said one of them. "My cattle are so thin that by using a sheet of carbon paper I can brand two of them at the same time."

On Company Time, Too

An office manager was telling about a girl who came in to apply for a job. When asked if she had any particular qualifications or unusual talents, she said she had won several prizes in crossword puzzles and slogan-writing contests.

"Sounds good," the manager told her, "but we want somebody who will be smart during office hours."

"Oh," said the girl, "this was during office hours."

Conceivably A Miracle

A young lady went to her doctor to have a routine checkup. The doctor smiled happily and said, "You are a very lucky young lady. You had better call your husband immediately."

"But I have no husband," she replied.

"Then you had better call your lover."

"But I have no lover."

"Then your best boy friend," the doctor frowned.

"I have no boy friends."

The doctor jumped up and ran to the window.

"What is it, doctor? Tell me the worst!"

Without turning the physician said, "Lady, the last time this happened there was a bright star in the east, and I don't want to miss it this time!"

Hurry Back, And Bring Your Friends

Lady of the Night to a customer: "It's a business to do pleasure with you, sir."

Reciprocal

"Strong, well-built men make amiable husbands," one writer says.

"So do strong, well-built women," writes another.

Fair Chance

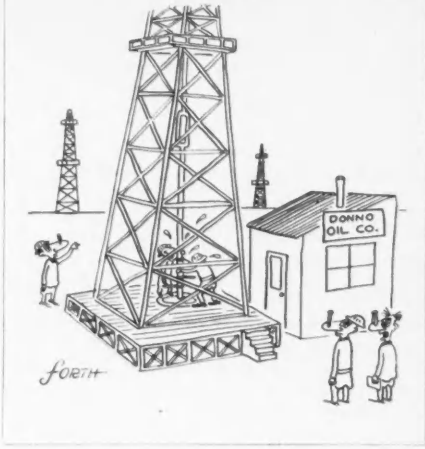
After the visitor had talked all evening about the size and fierceness of the mosquitoes, the old Texan was becoming much annoyed.

"Just look at them swarm," the guest complained. "Why don't you screen this porch?"

"That, suh," the old man replied, "would be unsportsmanlike. We use mouse traps."

Two-way Relief

Instead of using pills to get rid of headaches, some girls use headaches to get rid of pills.



"No wonder there's a foul odor—we had an outhouse in that spot a few weeks ago!"

Habitual Drunk

Wife to husband who had a few drinks too many: "If it were the first time, Henry, I could forgive you, but you came home like this in November, 1916."

LEAK PREVENTION THAT'S SURE ON EVERY JOINT!

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Have you tried Rectorseal on tubing lately? Continuous improvement since the war insures not only maximum leak resistance, but also increased plasticity—smoother flow, greater economy. Easy to apply with brush or swab. A little goes a long way! It's a 13 year favorite in the industry.

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A ELECTRIC WIRE LINE SERVICES

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2. **BRIDGING PLUGS**—Drillable, expandable. McCullough and Baker.
3. **MAGNA-TECTOR***—Locates stuck point of pipe, accurately, fast!
4. **JET CASING CUTTERS***—World's fastest casing, tubing, drill pipe cutter!
5. **JET BACK-OFF TOOL*** and **STRING SHOT**—World's fastest way to recover stuck pipe!
6. **JET BOTTOM HOLE CUTTERS***—Fragmentizes lost or stuck fish!
7. **ELECTRONIC WEIGHT INDICATOR***—Supersensitive, small, light!
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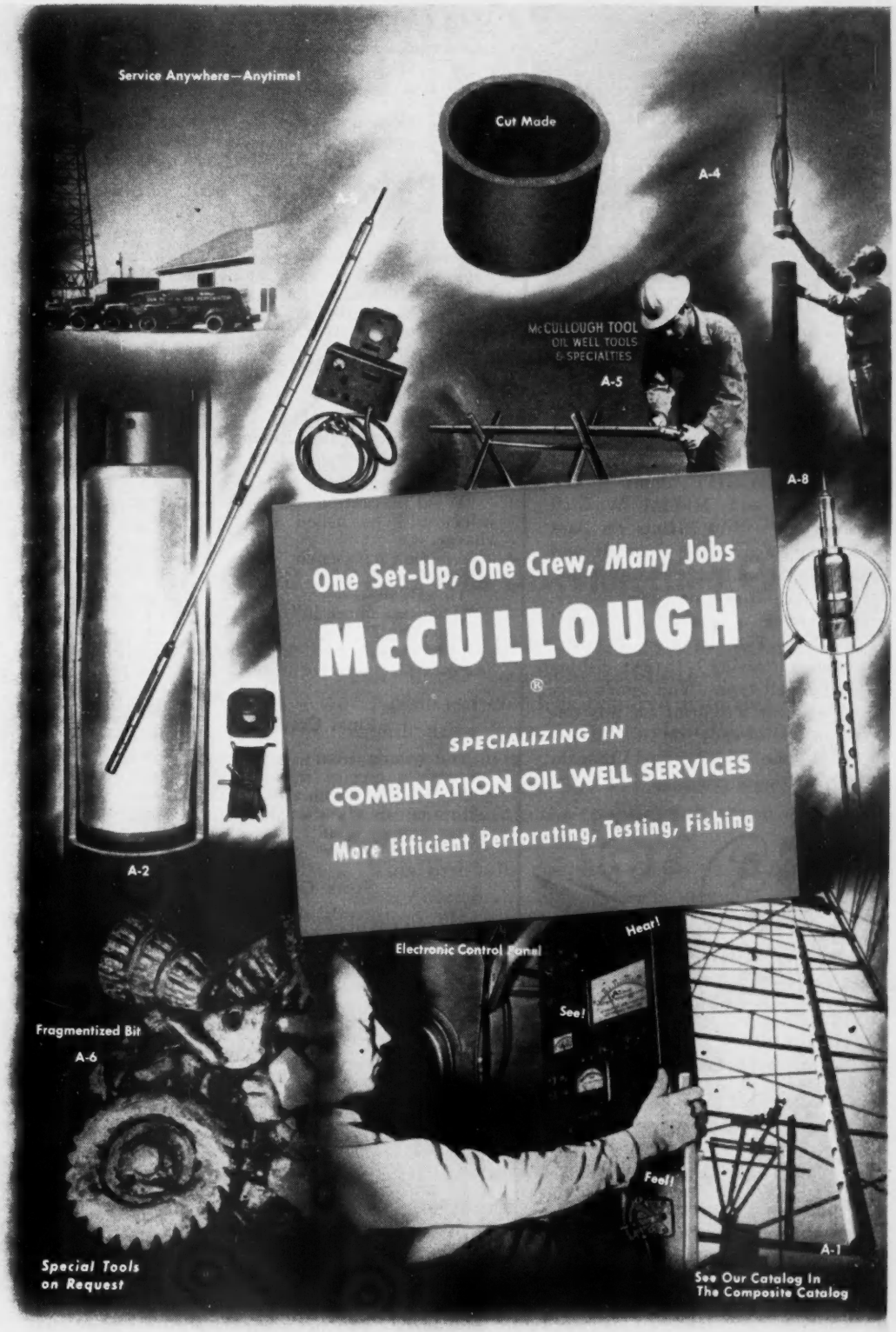
1. **DOUBLE ACTING ROTARY JARS*** and **BUMPER SUBS**—Reduces number of fishing jobs!
2. **SAFETY JOINTS**—Releases quickly in emergencies!
3. **EXTERNAL DRILL PIPE CUTTERS**—For all outside pipe cutting.
4. **MECHANICAL LONG KNIFE INTERNAL CASING CUTTERS**—All sizes pipe, tubing.
5. **THIN WALL EXTERNAL CASING CUTTERS***—For outside cutting in small clearances!
6. **ROTARY RELEASING OVERSHOTS**—Completely encircles fish.
7. **ROTARY RELEASING SPEARS**—Engages or disengages at will.
8. **GUN TESTER**—Water shut-off, perforating, testing in one run.

**Exclusive McCullough Services*



Ask your McCullough service man about time-saving *COMBINATIONS of these services*

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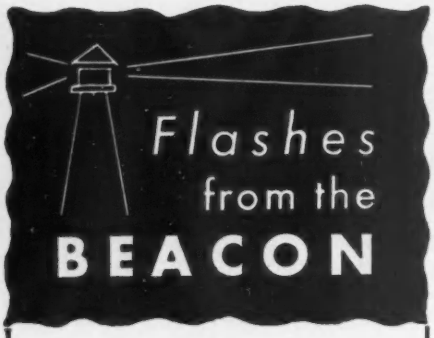

WE'RE THINKING of fishing . . . doesn't exactly pertain to our work or yours—except that a good fishing trip makes you feel more like settling down and getting a little work done.

* * *

WE THOUGHT about it last year too and Milford Waddell came out with a "Hints on Bass Fishing" article last July. It was so popular we had to reprint it and send it to fishermen everywhere. He's done it again . . . called "Let's Go Fishing," the article and pictures "review" latest fishing gear of all types. You won't have to wait for a reprint on this one if you're already on the list to receive the BS&B BEACON—the *different* industrial magazine.

* * *

"Pitch, h--l! Send somebody out here to get my leg down!"—a BEACON Original by Dave Hunt.

* * *

COMPANY publications have been called "special interest" pieces—and our "special interest" is interesting you, your secretary, your wife and kids, your barber—well, there just isn't anybody we don't want to interest. That's why we carry fiction, comment, reviews *besides* the latest news on BS&B oilfield equipment.

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SQUEAKS FROM THE BULLWHEEL

Sportive

Lady Godiva, we are told, was the greatest gambler in the world—she put her all on a horse. She didn't win, but she showed.

A New Twist

A man charged with breaking into a bank stated that he was in perfectly good health when he committed the crime, that he did not suffer from blackouts or split personality, and that he was not in need of psychoanalytical treatment. He said, "I just did it for the money."

Why Take Chances?

The medical officer was testing the water supply.

"What precautions do you take against infection?" he asked the sergeant in charge.

"We boil it first, sir," the sergeant replied.

"Good!"

"Then we filter it."

"Excellent!"

"And then," said the sergeant, "just for safety's sake, we drink beer."

Final Crack-up

The young man's head was bowed, as with a tremor in his voice he explained to his psychiatrist: "The trouble with me, sir, is that I'm from Texas and ashamed of it."

Scots Go Way

The Scotsman's experience was very embarrassing. He could have sworn the sign on the door read "Laddies."

"That new driller doesn't seem to mind these offshore locations."

Variation

Wolf to friend: Who was that lady I saw you outwit last night?

Thpitful Child

A naughty little girl was put in a clothes closet for punishment. For 15 long minutes there wasn't a sound. Finally the stern but anxious mother opened the door and peered inside.

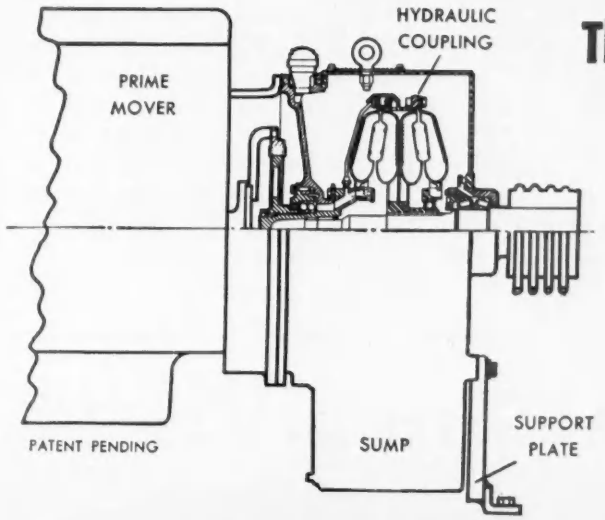
"What are you doing?" she asked.

From the darkness came the emphatic answer: "I'm thpitten' on your new hat, I'm thpitten on your new dreth, I'm thpitten on your new thatin thlippers, and—and . . ."

"And what!" cried the mother.

Came the voice of vengeance, "Now I'm waitin' for more thpit!"

Another great advancement in hydraulic drives for drilling equipment...



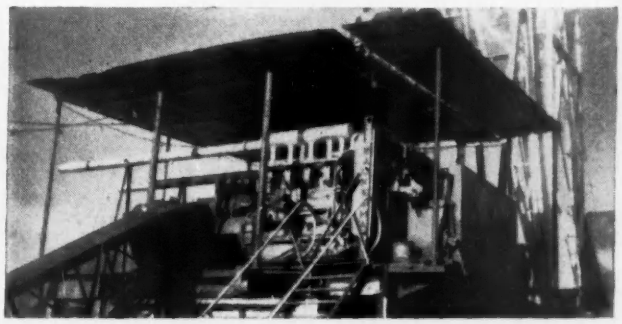
The *NEW* Twin Disconnecting Coupling

In the new Twin Disc Model HUD hydraulic unit, the "D" stands for *disconnecting.*

No master clutch is required with this hydraulic drive. For when a complete disconnect is desired, fluid is "dumped" from the coupling and held in a reservoir. This fluid is quickly pumped back into the coupling when you are again ready to pick up the load.

This hydraulic coupling serves as its own master clutch . . . has all the advantages of a hydraulic drive without sacrificing space. The Model HUD is a *compact* power unit in which shocks are dampened, the load picks up smoothly, and jerks and jolts in hoisting are eliminated.

And these advantages add up to cash savings . . . less maintenance, fewer replacements, more work done on every tower. You'll reduce costs when your rig is equipped with the *new* Twin Disc Model HUD Hydraulic Drive—the Twin *Disconnecting* Coupling.



O'Neal Drilling Company's Emsco GA-500 rig on location in Scurry County, Texas. *For complete information on how HUD disconnecting couplings speeded up production on this rig, write to Twin Disc.*

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CLUTCHES AND HYDRAULIC DRIVES

Clutches & Hydraulic Drives

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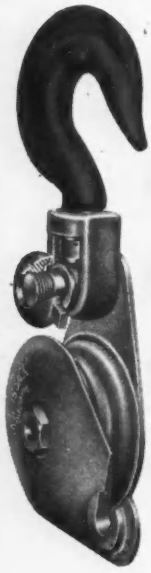
"Just call me Scottie McBlockhead for rigging a block the hard way"



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SQUEAKS FROM THE BULLWHEEL

The Last Reward

Rich Oldster: "We've known each other for so long, doctor, that I won't insult you by trying to pay now for your help. I'm leaving you a handsome legacy in my will."

Doctor: "That's very kind of you, I'm sure. By the way, just let me have that slip again. There's a slight change I want to make in your prescription."

Q. E. D.

"Mother, are there any skyscrapers in heaven?"

"No, son, engineers build skyscrapers."

T-t-talking P-p-point

"I hear you went to a school for stutterers," said the old friend. "Did it help you?"

"Peter Piper picked a peck of pickled peppers."

"Why that's wonderful!"

"Yes, but it's d-d-darned hard to w-w-work into an ordinary c-c-conversation."

No Consideration

They were holding an all-night party in a hotel room. As the party progressed, so did the sound of revelry. Finally, at 3 a.m., a weary guest in the adjoining room started to pound on the wall.

"Well, I must say," shouted one of the merrymakers indignantly, "this is a hell of a time to be hanging pictures!"

"One of the wells came in today and we're not supposed to waste a drop!"

Definitions With a Difference

Flood: A river too big for its bridges.

Pink Elephant: A beast of bourbon.

Sarong: A dish towel that made good.

Shot: That which, if some people have more than one, they're half.

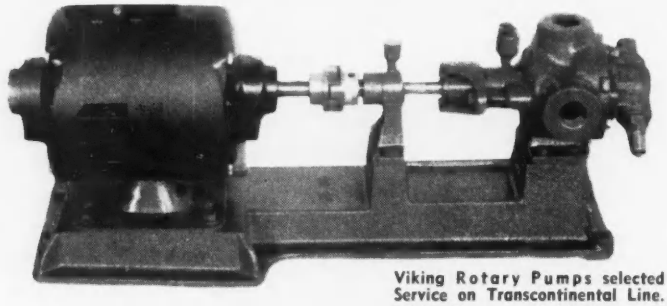
Virgin Pine: A tree that hasn't been axed yet.

Plenty of Nothing

On a recent quiz program, a contestant was asked, "What is the chief product exported from Washington, D. C.?"

"Waste paper!" was his prize-winning answer.

Dependable POWER for PUMPING



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